BEFORE THE

SECRETARY OF ENERGY ADVISORY BOARD

NATIONAL IGNITION FACILITY TASK FORCE REVIEW

SECOND MEETING

November 30, 1999
Livermore, California USA

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Meeting was held pursuant to Notice at a Conference Room of the Lawrence Livermore Laboratory, Livermore, California, USA, on the 30th day of November, 1999, commencing at 8:37 a.m. PT.

TRANSCRIPT OF PROCEEDINGS

THE CHAIR: Perhaps we ought to get started. And, let's see. We're approaching Godliness. Cleanliness is next to Godliness. I just wanted to see if Andy was awake.

So maybe we, we ought to get started, Mary.

DR. SPAETH: Good morning again.

THE CHAIR: Morning.

DR. SPAETH: Okay. So, today we're going to talk dirty. Or maybe we'll talk clean, okay?

And I heard, overheard somebody say that cleanliness is next to Godliness. You know, here we say Godliness is next to cleanliness.

Just as crooked as it was yesterday. Okay, so this is an overview of, or an outline of what I'm going to talk about.

I'm going to give just some background in general about the whole topic of, of cleanliness for --

DR. MOSES: Bring it into focus. That's important for this program.

DR. SPAETH: There we go. Thank you. I didn't know how to do it.

Background of cleanliness as it applies to ICF-type lasers, a little discussion about why cleanliness is important to us, in effect, and --

DR. RICHTER: Cleanliness is next to Godliness.

THE CHAIR: You obviously weren't in the room, Burt.

DR. RICHTER: If it's a good line it's worth twice.

DR. SPAETH: The language of cleanliness. That's the unit, how we talk about it.

Which one of those units are important to us, okay, the cleanliness is important for all the different pieces of NIF. And then our discussion on approaches to achieving cleanliness.

And it looks to me like a good time for a break would be right about here, okay? But we'll see how the time goes.

THE CHAIR: Okay.

DR. SPAETH: All right. You've seen this viewgraph in a number of ways over the last several days that you've been here, and I'm going to view it, look at it from the viewpoint of cleanliness. Cleanliness is something that we have had to worry about all of the time for every laser system, 1976, NIF, down to 2003.

But cleanliness as a concern for people who build lasers didn't start until 1976, either. Lasers were built in 1962, as I recall it.

I, I built my laser in 1963. It was a plasma ruby laser and you knew you had to get those ruby lasers clean. And you just have to get it clean or you're going to have troubles with that system.

So this is something that we've been concerned about all along this period of time, all right? And when we talk about cleanliness and when the specifications for cleanliness are for ICF lasers it's a little bit tricky because cleanliness in and of itself we could care less about, all right?

It's not a primary criterion. The primary thing that we're interested in is the economical operation of the system as we fire it.

And from a project point of view, while we're putting it together, while we're not operating it, our primary requirement is to make sure that whatever we do we make it possible to have economical operation once we have the system operating, okay? And so what we do is we try to make judgments.

We try to do analysis. We try to make everything in order to set spec. for cleanliness and contamination control, because those are the measurements and methods that we use to achieve the real requirements of economical system operation.

Okay, so, so the way that NIF has been designed from a fundamental point of view, in other words, we, you don't design the laser and then think about cleanliness. You think about cleanliness and then you design the laser, all right?

And so specs. that have, that have been in the design, first of all, just from the viewpoint of the standard industrial practice, the things that were done on Nova and the things that are being done on NIF, is that you qualify all of the materials that you're going to use. You go through a set of procedures in order to make sure that those materials are appropriate to put in a place that's clean.

And then a very important step that you

can't forget is you have to do QA and QC to make sure that the way that those materials were actually utilized inside your system meet the kind of conditions they would have to meet in order to be truly clean when you get them, all right?

And then another one that's just sort of standard in the practice is positive pressure. We have positive pressure on all of the atmospheric, all of the parts of the system which are at atmospheric pressure.

That's in and around the slabs, at the periscope, and, and around the transport mirrors. One is the transport mirrors are in argon and the others are in nitrogen, or probably in air.

All right, for Nova and NIF many of the basic systems for architecture were chosen because of the impact that they have on the way the system will stay or be able to be clean in the first place, or in this case, image relays and filters.

Those are the transport spatial filters, the two that you've seen. Those reduce the spiking on the laser making the laser less susceptible to dirt that might be on any of the optics along the way.

In addition to that we've put blast

shields, a protective layer of glass, between the flash lamps and the slabs. The, the flash lamp region is substantially dirtier than what we want around the slab.

Done in both Nova and NIF, we have vertical slab orientation. You've seen many times now the pictures of those slabs which are in there like that (demonstrating) so the dirt falls past the slabs rather than on the slabs.

All right, we have gas purge through the amplifiers, both Nova and NIF, you heard about yesterday.

And then the optics assembly. Air is in a Class 100 clean room, the part where we put the pieces together.

All right, the things new in NIF were the bottom-loading LRUs that you've seen all over the place, and I'll talk a little more about today. We have the transport of the LRU from the assembly area into the lasers in this transport system, the clean room that drives around.

We have a sealed low-pressure final optics assembly region in order to achieve -- If you're in a very low pressure region and you have dirt, what, what, what, what keeps the dirt out there in the air where it can fall on things or fall on, migrate and be knocked around is the air supporting it. If you have a low pressure is that dirt falls like a rock to the bottom of wherever it is.

All right, and then finally we added something to this flash field region in NIF which is a hermetic shield between the flash lamps and the slabs so that now dirt cannot even sneak around the edges.

Okay, one of the things that I also want to talk about right now is, before we go any further, is that we're not doing this by ourselves. We're not thinking about this problem by ourselves, all right?

In a manner that's been consistent with the laser program for some time, and it's continuing in NIF, we have collaboration with people in the various industries in the United States which are also concerned about cleanliness. We've taken a look in particular and said, "Where are the people who have lives that have problems like ours?"

And then primarily they're in the wafer fab and slab fab and transport parts of the world. And so we've emphasized the people that we have supporting us from these particular areas, all right?

These, these folks right here in large part are often living with us; not constantly, but when they are here they spend substantial amounts of time here.

**Ahmed Busmana spent his so-called summer vacation with us helping us working on any number of things that are related to our cleanliness issue. He was an essential part with figuring out the issues of putting gas purge in the amplifiers.

Don Wadkins has built, for 17 years has been building clean wafer slab facilities. He's developing the protocols for putting ours together.

Vern LaFavre from Lockheed-Martin, he spent his life putting satellites together and shipping them back and forth from the cape and everywhere. So he's helping us with the assembly procedures.

He's helping us design them, and then he's reviewing all of the documents that we put together and re-writing them as appropriate to make sure that they meet the specs., as he would say.

Tim Self is a, is a president of a consulting company. About 150 folks he has working with him that do consulting for high purity piping for industries all over the United States. He's the key guy in designing our plumbing and piping system.

All right, Astro Pack, Brent Ekstrand, you're going to see that facility perhaps; I don't know for sure whether or not you will, but I'll surely show you some pictures of it. This is for the cleaning of our large vessels and beam tubes.

And then <supedze> Hergain is lots of experiment in the technology. He's helping us put together all the technology that we send out to vendors on the type of cleaning and those parts that come back to us.

And we have a telephone set, other folks. Basically they're here for a few days or we call them on the telephone; we have a specific question and say, "Help us."

DR. VOGT: What's the middle?

DR. SPAETH: What's the middle? Oh, I'm going to tell you. Can you wait just for ten minutes? Okay.

Okay, you've seen this picture of the beam path before numbers of times. People have showed it to you.

This is what we use when we're talking about how the light gets down the systems and what the issues are with the light. If we take the same approach and we draw that, that system with, with regards to the cleanliness of the system it gets a little bit, a few more items on it.

This sustained cartoon, now what I've done for this one is I've highlighted in red those items of the system that we are most concerned with for cleanliness. You'll see that those are the surfaces of the slabs, the surfaces of the vacuum barriers at the spatial filters, both sets of them, the surfaces at the switch, all of the surfaces in the 3-Omega optics area, and the surface of this one diagnostic up here that's a diagnostic beam splitter at that location.

All right, so now I'm going to get to that part of the talk where I've said I'm going to talk about why cleanliness is important. All right, first of all we're worried about anything that happens to damage a laser slab.

Back in the back of the room there is a laser slab, and what I have in this box is a, a, a little hand-held self-supporting microscope. At the break we can take that microscope and look at some of the damage spots on that slab so you can see in the flesh what it is we're concerned about.

All right, we're also worried about

reduced transmission of the sol-gel coating. You say, "What is a sol-gel coating?" I'm going to tell you that one, too, in just a few moments.

All right, I think Ed related to you, but I'm going to explain to you the issues related to those with respect to cleanliness, and then I'm not really going to talk to you about this because Lloyd talked to you about it quite a bit yesterday other than to say that one of the things Lloyd is worried about is initiation sites.

If a piece of dirt gets on that 3-Omega it can be an initiation site just as well as any of the other kinds of defects that he talked about. So we find that it's very important to keep that area clean as well.

Okay, so this is what damage looks like to a laser slab, all right? This is not the same kind of damage that Lloyd talked to you about that burrows into the glass.

For the most part this is a surface phenomenon, all right, and it happens not because a laser light hits it for the most part. It happens for the most part because of things that happen when the flashlight is flashing and depositing energy on that service.

What happens is if you have a little bit of dirt on the surface, that dirt equilibrates with the temperature of the flash lamp. So that little piece of dirt can go up to something like 10,000 degrees in temperature.

And what it does, it's, that's hot. It transmits that heat to the surrounds.

That surrounds might be a piece of glass if it's laying (sic) on the surface and it crazes the surface like if you took a blow torch to the surface of the glass very quickly, would craze the glass. That's the kind of surface damage we see come on the laser glass for the most part.

All right, and when that diameter is first observed to the first order it, it's about eight times the size, or the area's about 64 times the size of the area of the piece of dirt which was on the glass. So it gets, it's a couple of orders of magnitude bigger in area on the space that it's impacting than the size of the dirt in the first place.

And that kind of damage is caused by all kinds of contaminates. The kinds we've tested and found, either found or deliberately put on the glass include these kinds of things and another list that goes down as long as your arm.

It's all the kinds of things that you find in the world and that you find in laser assemblies around them. Okay, so the first thing I want to talk about is: Why do we care?

You'll look at that piece of glass and unless you have that piece, that microscope with you when you're looking very closely, looks like a beautiful piece of glass. Why do we care that those little spots happen?

Okay, we care for a couple of reasons. The first spot, the first reason is the one that would just occur to you probably automatically without me talking to you about it, and that's that it can scatter light out of the beam and just become a loss of the laser energy, a loss term that just kicks light out, light that you would otherwise be able to use.

And when it's doing that it's also increasing the beam modulation. "Modulation" is the term we use to talk about the spikiness on the beam.

So if there's something in the path of the beam, all right, it's going to make a little hole. And that little hole is going to have a spikiness that grows.

So, overall it's going to contribute to that modulation which overall in the end is going to affect the fuse. The fuse is the 3-Omega optics.

Our optical fuse is we design the system so that 3-Omega optics are at their maximum stress level. We do that because otherwise we would be wasting all of the capital everywhere else in the system, all right.

But that means we have to keep that modulation to the minimum level that we can, that we can imagine. All right, so let's look at what happens when you put a little piece of dirt on a piece of glass downstream, because it turns out that in many cases this is the thing that we worry about more than that loss to the laser light.

And that's something that has kind of a funny name, which is called hot focusing of obscurations. All right, so what is that?

We put a little piece of dirt here. Remember, we have a laser beam which is moving along this, this direction right here.

The intensity profile of that laser beam right here, assuming that we're doing things perfectly all right, would come up like this, go in, across, and come down here so what we're looking at is the profile of the laser light.

You don't want to have a very sharp edge because that would lead to all kinds of modulation downstream. This little soft stream is comcentrically to give you maximum energy out of the lasers and minimum modulation downstream, that configuration.

So, that's the shape. Now it comes and sees the little piece of dirt. When it sees the piece of dirt it puts a black spot. There is no intensity where that piece of dirt, or where that damage spot was.

* All right, now because light has a wave nature we're going to get ringing. We're going to see the impact of that ringing, or the impact turn up in rings around the location of where that damage spot was.

And as a, the beam propagates through the system, that ring is going to get bigger, all right? Now, what happens is that in a, the light intensity in the laser slabs is so intense that the index of refraction is a function of the intensity of the light, all right?

So that where the light intensity is higher, the index of refraction is higher in the glass. When the light intensity is lower, the index of refraction is lower.

So, when that happens right at somewhere around in here we're having a pattern of the intensity of the light that looks something like this in the slab, and now what we're doing is we're making little rings that have different index of refraction as you go out. Those different index of refraction is making this thing behave just like a Fresnel lens.

All right, so now the size of the, the damage spot was little tiny, but the size of the Fresnel lens that is now being able to drag energy out of the main beam is substantially larger than the size of that original damage spot, all right. And then as that Fresnel lens which is being generated by this damage spot collects energy out of the beam, it focuses back downstream someplace else in the laser system, causing a very high bit of modulation.

Now, where we're particularly concerned about that happening is at one of the vacuum barriers. I've drawn this like a lens, and that's because I've drawn it to indicate in a cartoony sort of way that this could be the entrance length or the safety spatial filter, for example.

And if that damage spot, if this impact of this Fresnel lens is focused on the back spot, the back sides of that lens, that's where maximum stress is on that lens because of the vacuum that's in after the spatial filter, and where the system is most susceptible to damage. This is one of the health and safety issues that we worry about for the system.

I mean, there are layers and layers that we are protecting on that, that system, but one of the layers is not to ever let that damage spot occur in the first place, all right? And so we put limits on the size of this damage that can occur at various places along this chain so that we don't cause a damage spot down here that would cause the kind of problem that I just alluded to.

All right, so that's why we care about damage on surfaces, on optic surfaces. Now, why do we care about damage, why do we care about dirt being on the sides of the vessel?

What, what are they harm-, what harm are they over there on the sides of the vessel? Generally when you have a small particle on the surface they're very hard to discharge.

They are held on by van der Waals or electrostatic forces, and these are very high G forces. They can hold very tightly if they're a very small particle.

What happens, as Ed likes to say, the second biggest problem with the second biggest generator will be ghosts. So when we have scattering, that scattering still represents very large amounts of energy, and that energy is coming out at something like 20 to 30 nanoseconds.

So when that scattered light hits the surface of the vessels, a small area -- I'm sorry. I went the wrong way. And what it does, it just pops, pops the dust particles, those small little forces of thousands of G, in that category, can pop those particles off the surface, then letting them go wherever they would go.

They're just free, free, free particles, and can then again give us the concern for the optical surfaces once more.

All right, and then I also talked a little bit about these nonvolatile residues yesterday, although I might not have called them that. These were the organics that we talked about settling on the walls.

They're everywhere. You can't avoid them.

You can minimize them, but you can't avoid them. All right, when they're flash pyrolyzed by the flash lamps they can become aerosols and they can settle on optical surfaces as well.

Okay, so now I'm going to talk about sol-gel coatings for a moment. What are sol-gel coatings?

Okay. All right. People have made their reflection coatings such as many of you and I have on my glasses, which we want to be able to see things clearly without distortion, so we put these on some of your glasses.

Well, sol-gel antireflection coatings have been here, around since the '60s. They were reduced to a practical form at Livermore in the early '80s.

They have very high damage thresholds. The kind of coatings on my glasses would damage, at the regions where the lasers want to use them they would damage.

There are some work going on, but certainly historically they damage. They have low manufacturing cost, and they get very good reflectivity, in the range of a-tenth of a percent to .25 percent when the coatings are new.

Okay, how do these things work? What they do, they're dipped in a solution, an alcohol that becomes silica, SiO2, and that, as you pull that out of here to the surface, as you pull the surfaces out of the solution and they form these microballs of silica, but the microballs are porous within them and they are porous between them, and so what you form, it is a graded index.

You have a graded index material with a density which is selected such that it has just the right index of reflection to refraction to make the reflectivity from here to the glass substrate very, very small. All right, so this is a micrograph of what it looks like.

This particular one is a 3-Omega coating, and you can see the size of the balls. And a-quarter wavelength at 3-Omega. And this is from a little bit different angling so you can see now you're looking down on the coating.

You can see what the morphology of this thing looks like, okay? You can see they are very porous structures, like I say, not only between the balls, but within the balls.

The surface area at 1-Omega is about 100 times any particular piece of surface as the surface area of the thing that it's covering, and so because of this very large surface area, it can act as a getter for contaminants.

All right, so when those contaminants get in the coating, they increase the reflective index. They increase the reflectivity and decrease this transmission, increasing the amount of ghosts that you have bouncing around the place.

Now, how does that contamination get in there? Well, it gets in there because you have a vapor pressure for those things that are on the walls, those organics that are on the walls.

They have a vapor pressure, all right, particularly in the vacuum areas. Those particles, when they leave the wall, can move very, very rapidly to the surfaces that are sol-gel coated. And because this has a very large effective surface area it can act as a, as a, there can be mass transport from here onto the sol-gel coated surface.

All right, in the regions which are near atmospheric pressure the same issue happens, but it happens at a much slower rate because it's slowed down by diffusion. So it might take months or years to happen in atmosphere. In the vacuum conditions it can happen in hours, all right?

I realize that when I looked over my viewgraphs last night I hadn't shown you some of the things that we were doing about this besides cleanliness, so I don't want you to think that this topic of the sol-gel coating problem is being un-, un-, unwatched over and being dealt with on a regular basis.

This is the sol-gel coating as we put it on as a function. This is, this is the, the weight absorbed, and I want -- Well, I don't have the one I want.

This, this shows you the -- This, I picked this up very rapidly this morning. What happens is the reflectivity is doing something like these curves, although I don't have the one that has reflectivity over here.

So, as we put it on as it's, as we get it out of, out of that box and let it dry, the impact of the contaminants is very high. We're looking at a variety of ways to treat that surfaces, to harden that surfaces, to reduce the porosity in ways that we can reduce the sensitivity.

That doesn't mean it's not sensitive. It just has lower sensitivity to the impact of the contaminants.

So, both are important. Doing these kinds of things are important, and keeping the MVRs off the walls are important. So that's sort of: Why is it cleanliness is important to us?

All right, now we want to talk about what are the things in the NIF system that have to be clean. Well, there have to be some level of cleanliness everywhere we work.

And the applications where we work are in the fab. lab.; either the laser bay or the switchyard or the target bay, all right? in the, in the optics assembly building where we put the LRUs together; in the, the OPDL, another place where we clean optics and get them ready, process optics and get them ready; and in the amplifier assembly rooms, those big boxes that go around the assembly area, these guys right here. Where those are assembled has to be cleaned.

Then inside the beam path, inside the vacuum vessels, the cavity spatial filter, and the transport spatial filter, and the vessels that are with them, they have to be cleaned. The final optics beam path we've talked about yesterday, this is the main laser beam path, all optical surfaces anywhere, in the target chamber and inside the injection lasers closure where everything starts.

All right, and then inside any volumes that connect to this beam path which is the utilities, first of all, the utilities that are downstream of the filters, the filters that protect the laser. Somewhere in here there's a filter, all right?

And so the utilities downstream of the filter have to be as clean as the beam path, but utilities upstream of the filter can be somewhat less clean. All right, the flash lamp utilities is similar, and those transportation vehicles that we've talked about in the past.

So now I just want to review: Where are all those things? All right?

From a physical point of view the things that we worry about, here's that L-path, okay? The OAB is right next to it, with an adjoining corridor.

There's the FAU assembly area. Here's the OPDL, and we store things.

Some things come in clean, clean and packaged. We store these things over in the warehouse. We've tried to store these things close together so our, our transportation issues are minimized, all right?

Inside, the next thing that have to be clean were those things inside the beam path. Remember, that beam path goes here, up, and then here, right?

And then onto the switchyard and into the target chamber. So that's where the beam path is, and these are some of those utilities.

You can see them here. Same things here.

Okay, so now let's just talk in a little bit more particularly, and I'm, there's some units on here I'm not going to quite get to, but how were these various pieces where we have things cleaned compared to other things that you're familiar with? All right.

First of all, the, my base, the laser bay, the switchyard, and the target bay basically to first order, they're about as clean as your house, maybe about as clean as this room, okay? We took a measurement of this room half an hour ago, okay? It was about 50,000 compared to this number right here of 100,000, so about as clean as this room, okay?

They have a 49-foot ceiling, zero external filters, the flow-through in the system is about 11 feet per minute, and there's about 14 air changes per hour in, in, in those bays.

All right, now let's talk about OAB, where we clean parts that are going to be going into parts that will be the assembly. In those parts we, we'll get to what this number means, Class 1,000.

That's typical for the kind of facilities where you'd put a satellite together, all right? They have, in our OAB we have 14-feet ceilings, 35 to 50 terminal filters, little higher velocity, and about 160 air changes per minute (sic).

Okay. All right.

And then in the places where we actually do the assembly we're in something like Class 100, all right? Similar to work in a pharmaceutical or some of the older wafer fab places.

Okay, again, 14-foot ceilings, this kind of stuff, 320 air changes per minute (sic), and --

DR. RICHTER: Why does it make sense to do your assembly in a cleaner place than you did your cleaning? It's already dirty at the Class 1,000 level.

DR. SPAETH: Well, we're going to talk about something called "exposure." How much time, how much dirt it is.

Remember, we don't really care what is in the area around us much of the time. We care what is on the surface.

DR. RICHTER: Uh-huh.

DR. SPAETH: Okay, so when those surfaces are being cleaned in their cleaning vats, the, the ultimate sonic cleaners, whatever, those surfaces are very clean, all right? And if they come out of there and they have little time in which they are exposed to that level of cleanliness and wrapped, they'll still stay clean, all right?

So as long as they're contained with a short exposure time, the cleanliness of the room doesn't have to be as severe. The assembly areas, they're exposed for a longer period of time and so the cleanliness of the room has to be better.

Okay, and then let's talk about -- Well, first of all, before we get to this one, let's talk about this thing in general. What, where does the dirt come from?

Okay? For the most part the dirt comes from people. All right, we are very dirty things.

We emit dirt, all right? We carry around dirt, and we kick up dirt, all right? So that the places that are making all of these things dirty were the activities or the, or the mere presence of the people.

All right, so now we come to we talk about the clean, this, the, the, the beamline. The beamline doesn't have any people in it, okay?

The beamline has things. The thing that makes things dirty in the beamline are those flash lamps or those ghosts that are kicking around, all right?

So in the beamline we were aiming for Class 1. All right, they are about 17 in height. They have 100-percent terminal filters.

Every one these things is term-, is, is terminal in the filter before it goes to beamline. Okay, the velocity around the slaps is about two feet per minute, and those are consistent with that calculation I showed you yesterday, all right?

And we have about 20 air exchanges per hour in that region with that 30-percent volume flow that I talked to you about yesterday.

Okay, so now I want to talk a little bit about niche boxes, okay? I, I want to use this as a cartoon that I'm going to use repeatedly during the day, during this morning, to go back and forth to talk about different issues that we're facing.

All right, so the general strategy you have probably figured out for the long-term operation of NIF is to have areas that are very clean where we clean the parts, to take a transportation vehicle over here, to take that very clean part to drop it in this mini clean room, to then take that transportation vehicle with its little mini clean room operating to bring it over, and then to stuff the LRU into the beamline where it belongs via a very clean exchange mechanism.

And I believe you saw some of these parts in, on your tour the other day. All right, so this approach, this SMIF, we call this a SMIF box approach.

And we didn't, we didn't imagine this term. The semiconductor people made this SMIF. It stands for "Standard Mechanical Interface," all right?

And this is where it came from. This, here's a stack of wafers that are in a, in a real SMIF box, okay, and the semiconductor industry has standardized on the interfaces for what these kind of containers are.

I can get a container, a SMIF box made

by one manufacturer and have it fit perfectly into a facility that's doing something else that's made by another manufacturer because the standards have been established for what that interface should be.

All right this wants to be a Class 1. It's going to travel through rooms which are substantially dirtier than that as it gets there, and so we are mimicking the success that the semiconductor industry has had with this approach when we use this SMIF, SMIF box approach.

All right, so you know all the tests that we have done today are, look very good. They're very encouraging.

We're happy with the way that's going, so this part of the system, this would correspond with the long-range operational point of view of NIF that Ed had yesterday. Looks fine.

All right, the issues that we're faced with, then, is that this high bay is a relatively dirty place. It's as clean as this room, which is not very clean.

All right, how are we going to take these parts which need to be very clean and need to have walls that are very clean, and put them together in a situation that is dirty where it's much more difficult to limit the type, to limit the exposure of what's going on than it is when you're just taking something out of an ultrasonic cleaner and putting it over there?

All right, so this is the challenge: How do we assemble a clean beam path in a dirty room?

Okay, now I'm going to switch to that part of the topic that I talked to you about with the language of the clean room. So far I've been very, very glib and very fast and loose with "dirty," "clean," and et cetera, and things like that.

What I'd like to do now is talk a little bit more about: What are the units that I'm talking about? And what do we mean by these units?

Okay, so we characterize areas in two ways. We characterize volumes and we characterize surfaces.

So what I've, what, what, what is drawn here is a volume, and at the bottom of this volume there is a surface, all right? So volumes are characterized by a parameter called their class, and that class is measured as particles per cubic foot which are greater than .5 micron of a certain amount.

For example, I'm going to show you -- Here, let's, let's, let's switch right here to this next viewgraph and then go back to this one.

Okay, so read the yellow box first of all. The intersection of 100 particles per cubic foot with a particle size of .5 microns defines a Class 1 aerosol. This is a page out of my standard 209-E, all right?

And so what you have is a series of lines, and these lines represent, by the way, a distribution of particle size.

If you, if you studied the particulate or aerosol formation, you find out there's a general character that's common, or all aerosol, whether they come from smoke stacks, the exhaust in your car, a laser, or wherever they come from, they have the same general character, is that there are a lot more of the little ones than there are of the big ones.

And in general, the, the, the relationship is, plots as a straight line on a log, log path between the numbers there are at the various sizes, okay? So we look at this line here.

This line is called a Class 100, and at that point we've got, we read the particles .5 microns, so this is the number of particles that are greater than.

The ways these, these are, these are

like some, the number of particles that are greater than that size, and each point is read greater than that size. So this is the number of particles greater than .5 micron crossing the line of 100 particles per foot.

The atmosphere that is characterized by that line is called a Class 100 environment.

Okay, so now let's go back and look at the other ones, all right? There's a similar thing that's done for surfaces and particles, and that is that particles are measured as levels, and that's the particles per square foot, square foot now because we've got area, that are greater than, not .5 microns, but 5 microns.

And this is what the curve there looks, as far as federal standard for that one. Now, this is something of an unusual curve.

The last one was just a log, log blot. Okay, this is a log, and look at this curve.

There's a decade, there's a decade, there's a decade. Okay, this is unusual, but this is the standard.

I'm sure they knew what they're talking about, okay? And if you look at these, are sort of visibly dirty, these are visibly clean, and these are very, very scattered surfaces.

And these are the things we're looking at Level 50 for the large optics, Level 100 for the structures around the optic, and then the target chamber, which makes itself dirty from the debris of the target going off, the Level 300.

All right, so now we've talked about particles and volumes and on surfaces. Now let's talk a little bit about organics.

Organics were measured for the volume at partial pressure, all right, parts per million, something like that. And when they're on surfaces, we measure them as nonvoluntarily time residue in your, as we've talked about earlier, and those were characterized by letters of the alphabet, all right?

And I will show you those in a moment, but before I get to those I want to just talk about what the levels are for all those places. We talked about the areas that needed to be clean. Now we talk about how clean they need to be.

And this chart, from both the viewpoint of the volumetric cleanliness and from the surface, the surface cleanliness as we put this system together, and I think we've mentioned those numbers well enough long, there's probably not any big surprises as you look at that chart.

Now, there's one thing that's also important that we alluded to a little bit, a few moments ago, okay, is that exposure is -- Let me skip that sentence. Let me go back a sentence.

There is a relationship between what the atmospheric level is in the volume of this box and the, the level, that is the class of this box, and the level of surface particulates that show up on the bottom.

Let's suppose that we took that box and we've closed it off. We don't let anything in and we don't disturb it. What's going to happen?

Okay, the stuff that's in the air is going to fall as its terminal velocity until it hits the floor. And some of the bigger ones happen pretty fast -- within a-half an hour. And so a lot of them will be on the ground, all right?

And so however, how dirty this gets is, is a measure, or is, will be represented by how dirty the atmosphere was when we started this little experiment, all right? And so the time that you have a surface exposed to a class above it, the product of the surface and the time we call the "exposure," all right?

And so the, the exposure is the amount, is the product of the class times the time it was exposed to that class. And the level that we want, or the level that we will get if we do that kind of exposure can be found mathematically.

We can write this as with, if we know the air currents, you know. I mean, it's a rough calculation because you have to know those air currents very well to do it exactly, but you can at least get a rough measure of what's going to be.

All right? And so we've done that rough measure. And we say, "Okay, if we want levels to be no worse than a Level 100 in our laser, then what kind of exposure can this particular thing has (sic) as we're putting it all together?"

We can calculate then the bundles that we have, and how we have to operate all of our systems. All right, so this is the result of that calculation.

We start with a Level 83 surface as it comes from a particular part of our cleaning process. As we are installing it in system we will allow it to go up to a Level 100 surface, and, and we can calculate putting the numbers in for the kind of situation we expect.

We find that this, we get an allowable exposure of 20,000 class hours for being able to put things together in this dirty atmosphere, all right? Now we want to go back to this one a little bit and talk just a bit about that NVR, the NVR here one more, one more time.

I don't think that we need to spend hardly any time on this. This is just once again to represent that the partial pressure -- We do that same sort of analysis for the organics, the volume, and the level.

It's now not driven by gravity. It's driven by the partial pressure of whatever is hitting the wall.

We can calculate in a similar way we did with level what we can have on, what kind of things can be allowed to be on the wall in order to keep the partial pressure here at a certain point so that won't drive some other contamination point somewhere else in the system.

And then as a measure this is where I want to tell you a little bit about that they're characterized by letters of the alphabet. So if, if we have this level, a microgram per square centimeter of organics on the surfaces of the tiers, then they're characterized by these letters of the alphabet.

They started out, no doubt, with these, and then they figured out how to make things cleaner and so there were, there were no letters left above A. And so we just decided to do A over 5, A over 3, A over 10, et cetera, okay?

At an A over 10 you're at approximately .37 nanometers thick. Your average at top is about .2 to .37 nanometers, so you're looking at a little bit more than a monolayer or so on average when you're at an A over 10 level for your surfaces.

Okay, the next one I'm just going to skip. It's a little bit esoteric, which we use, but I think we can manage to skip for today's discussion.

So now if we add to our chart not just particles that we've looked at before, but we also add the organic concentrations that we are allowed at various places on this system, you'll see these numbers. And there's a reference to that chart that I skipped which is important to us, but it really is something that is a little bit more detailed than we want to talk about today.

Okay, so now we go back to our question about how do we assemble a, clean parts in a dirty, in a dirty room? All right, first of all we start out by cleaning the parts and we package them for transport.

All right, let's talk about how this was done in the past.

You know, this might be a good place to take that break. What do you think? I can, I can keep going. Bob says keep going. Okay, I'll keep going.

Okay. Same old chart again. Here are the years.

How do we do Sheba and Nova? Because we were very concerned about cleaning, cleaning there. You know, I mean, Emmett was, you know, he hyperventalated on the topic of having things clean. Okay, so how do we do it then?

Well, what we did was a high-pressure spray wash using freon. Now we didn't know about NVRs at that point.

That level of thinking hadn't occurred to us. We were concerned about particulates, but that freon we now believe was cleaning those NVRs up like crazy, getting not just the particulates, but also the organics off the walls.

Okay, so after we put those guys

together, what happened? Okay, we realized that freon was not a good idea to spray around the atmosphere in fairly large quantities, all right?

And so the use of freon by international treaty was forbidden to us beyond that point in time. So what happened?

Well, the Laboratory as a whole, Engineering Department put together a package, and supported in collaboration with the Laser Department, put together a package of, or a whole set of activities of looking for alternatives to cleaning with freon. And these are some of the things that that, that they looked at.

They looked at -- And, and they did very careful qualification of all of these opportunities, all right? Cleaning with CO2. You know, if in a, in a, in a dust form.

Cleaning with high-pressure water wash. Sometimes this water wash had a detergent mixed with it. Sometimes it was a water wash with a detergent followed by a pure-water wash, pure-water rinse, all right?

Sometimes it was organics that were being wiped and cleaned off the surfaces. Steam cleaning and vacuum cleaning.

And these things were characterized to give the following kinds of results: All right, so you see that neither steam cleaning or vacuum cleaning looked all that great compared to the other alternatives.

But wiping with some of the -- This particular one was isopropyl alcohol. Looked at using CO2 cleaning, and using with high-pressure water were normally in the same categories of things that, that you would be concerned with.

So now you have to think about: What are the other aspects of the job other than getting the job clean, or parts clean? Well, you also have to worry about how well they get the NVRs off, and you have to worry about whether or not you can actually do this in the real world for that particular part.

And you have to worry about how much it costs to do that kind of stuff in the real world, all right? So when you throw in all the rest of those tradeoffs, what comes off is, in many cases, for many different things, the best solution, and which, by the way, works damn near well as freon, high-pressure freon wash, is plain old soap and water, all right?

It's the high-pressure, really

high-pressure surfactant spray. Surfactant has got a detergent in it, the water, followed by a hot high-pressure water rinse.

And Beamlet, a lot of the parts for Beamlet were cleaned that way. Not the big ones, because we didn't have the big capability.

But anything that was small enough to fit in the cleaning chambers we done, we used were cleaned that way. And in NIF you can see we've made preparations to clean even the very large parts in this fashion.

Okay, so here's a picture. What we did was we, we put together a, a, a package, a procurement package to look across the United States for who could clean vessels at the size that we needed.

There are very few, all right? Astro Pack was one of them.

Astro Pack won that competitive process, and they've put together a facility on site for cleaning our very large vessels. And this is one of our vessels cleaned. I say it's local on site. It's a little bit off.

It's not within the bounds, but it's in very close driving range as far as, as, the transportation concerns are the same as if it were on site, all right? So Astro Pack for cleaning these vessels.

And they have demonstrated containment. We're removing surface particles to Level 8, so, which is what we, beyond averaged NVRs to the A-over-10 level.

Here's a picture then what we say, and that other bullet is. And we package them for delivery, all right?

So here we are. Here, that's in that 10-to- clean room in a warehouse in Astro Pack facility near here where we've packaged one of the center vessels for, looks likes a center vessel at least, for a delivery over to the L Tab.

And we've adapted a piece of Air Force equipment, all right, be able to handle -- This particular one is a 40-ton vessel. Okay, you can't just pick that up like a tea cup, all right?

You have to have special handling equipment, special transportation equipment to deal with it, package it, wrap it and move it over to where it's to be, all right? And so that's also being done locally here right next to, to Livermore.

DR. BYER: What are the organic

outcasts of the properties of the wrapping material?

DR. SPAETH: Well, actually I'm not in the room right now, so I can't tell you exactly, but we've done -- They ain't vinyl. We've done, we've done a survey of all of the, all of the, all of the materials that are available, and, you know, it's like it's not substantially alter the NVR levels that we, you would pick up in the room unless you get into two- to three-year timeframe.

Okay, so our next step, we clean the parts. We package them for transport.

Now we have to transport, clean and packaged, to the L-Tab, and we have to make the connections while staying within this maximum allowable class/time product that we talked about before, all right? So I'm going to skip that transportation one.

I'd let you trust me that we, we have figured out how to carry them. Lab has good rigors, okay?

And let's talk about what the problem is of actually making these connections now. All right?

Let's look at one laser bay, for example, all right? And the number of closures in one laser bay is about 60, pardon me, 600, and we call these flange-to-flange because it's one flange coming up and meeting with another flange, right?

All right, these are the typical number of connections per bundle as you look along, along a beamline. So it's non-, it's a nontrivial issue, nontrivial problem.

All right, if we take that and we look a little bit wider view at the entire L-pad, and put those 600 closures per beamline, pardon me, per, per, per laser bay in addition to these flange-to-flangetype connections, there's about 1,000 piping connections going on through these utility guys over here, all right?

In addition to that, in the switchyard there are around 400 connections in the switchyard, and another 500 connections in the region of the target bays, all right? So a total of something like 4,500 connections that we have to make clean in order to put this sucker together.

All right, now let's look at the kind of conditions under which these connections are being made. All right? These are the kinds of things that are happening in, over the time as we're putting it together, all right?

Here we're open to the outside. Means we were dirty.

Here we've got a roll-up door. Means we're somewhat cleaner.

We can manage by opening and closing that door to let things in for small periods of time. We can manage the time that dirt is allowed to blow into the building from the outside.

We still have to have this door open still, because we're still bringing big things in. Okay, after this point in time we've got all the big guys in and now we can close that roll-up door permanently.

But we've still got tasks going on inside the building that are dirty. We have constructional materials that are going on in this timeframe.

We've got welding and grinding going on, all right? These are generating dirt in a variety of sorts.

All right, we've got the crane in use, which is also generating dust as it moves around. All right, at the same time these things are making dirt, we're putting these things together which want to be in a clean space.

Okay, so in this time we're setting the vessels. As we're bringing these heavy things in, we're putting them in place. And then as the building is closed, we're bringing in, through smaller doors, doors that have air locks, the amplifier FAUs and installed beam tubes.

And these FAUs have their own clean bus that drives them around. It's a clean room that drives them around the facility.

Okay, so we have, in working with Don Wadkins we've set up protocols of what can happen or what needs to be going on in the building, what work needs to have been performed in order to have these things, to have these things, things be able to happen in parallel with each other.

And then you might notice how, how busy are we making the connections with some of our schedules that we're looking at. These are the number of connections that are happening per month, 180, 180, and this goes on for some period of time. So this, you know, we're, we're busy all right.

DR. RICHTER: Goes on for 30 months?

DR. SPAETH: It goes on for as many months as it takes. These are only the flange-to-flangeconnections. And there's about half of those.

DR. RICHTER: But you said there were about 6,000.

DR. SPAETH: Right. But half of those are flange-to-flange, half of those. So all of those 4,500 were not the big ones.

Any number are substantially smaller ones, so it's a little bit easier. And some of those are pig welded in piping things, and those are particularly easier to do.

Okay, so we say, "All right, now let's look at that requirement that we have." We've told ourselves that we could have 20,000 class hours in order to do this, all right?

And we have looked at that kind of busy activity, the kind of things that are going on in, in a nearby -- As I say, we need, we need a safety factor in here.

We're not going to push it to 20,000 class hours. We're going to have a safety factor of about four.

This is a bit arbitrary. This is a bit of a -- Okay, and so we say we will allow ourselves as guidance to figure out how to do that a number of 20,000 class hours in order to make every one of those connections, all right?

So let's look a little more clearly at the L-Tab, okay? What does the L-Tab look like?

All right, you see this piece right here? Well, first of all, some people have been confused by this picture.

This is up, okay? This is the ground, all right?

You see this piece right here? Okay, you're looking at that piece right here, a section.

You're looking at, you know, you're looking at this much of it. That's what, that's what you're looking at here, all right?

You can see it's busy. Okay? This is where the lasers go, all right? This is where the lasers go over here, all right? This is stuff which is underneath the lasers: piping, plumbing racks, all the kinds of things that support it.

Okay, so when you have clean room, normally you try to have laminar flow in an area to make sure that that gas is really going by and taking all the dirt out of it. It's fairly hard to imagine laminar flow in a, in a, in a region which is as congested as this one.

So what we have is very clean air

coming in, hepa filters, very clean air. We have very good air removal.

All right, what we have is a very congested area in the middle, so this particular room is rated at a Class 100,000, and we have 5,000 class hours to work to make the connection. And so we take that number and that number, we find that the time we have for every connection is three minutes.

Well, you see, you know, probably a flag being raised here. Okay, our experience is that we can't do it in three minutes.

Our experience, in fact -- And I'm going to show you a little bit how we gain this experience in a little bit. -- is that it takes on the order of 30 to 60 minutes to make one of these connections, and that's if we're all ready, you know, everything ready: this here, this here, this here. Take it off. Humph, everything together, all right?

And so it's apparent to us that it's going to be important that we make these connections in an area which is locally much cleaner than the room might be characterized at. And the way Ed likes to characterize this as a physician. His wife's a physician.

You go to the hospital and you get a

shot. You can go in filthy. They could care.

They role up your sleeve, swab the area clean, take that clean needle and jab it in and pump it out and the skin seals. Now, nobody, none of that dirt that's all over you got into that wound because locally you were very clean, all right?

And that's the same kind of thinking that we have to have when we're putting this system together, all right? We have to make a spot in that area which is clean even though the entire room may not be that way at all times, okay?

So one of the working groups that we have in Systems Engineering is called the Flange-to-Flange Working Group. And as their name implies, they worry about this kind of problem.

The kind of things that they worry about are: What kind of protocols do you have to accomplish in order to make this kind of connection possible? What kind of protective covers?

These are the ones that you just asked me about. How do you pick them?

How do you critique them for being picked? Okay, what is the sequence for how you put that, those closures next to each other?

What do you have ready? What do you

take apart when you're getting, and how much do you kindly close the, close the, in the open region?

All right. And then one that's also important to us that, just as you know the technician's and the mechanical engineer's place is what do you do with those confounded gaskets that you have all over the place that, that like to fall out, okay?

Another thing that this Flange, the Flange Working Group has been responsible for has been experimental evaluations of this connection procedure and the associated protocol to have to go with that connection that, that you would really need for clean assembly of full-sized NIF, like closures, all right? Not somebody else's parts; our parts.

All right. So in working to figure out what those protocols are, they worked with Don Wadkins and a number of other people who have expertise in this area, and we've broke, broken them down into those things that needed to be done generally to keep the building clean, those things that need to be done once the building is pressurized.

Now we start wearing booties and do wipe-downs and you use smoke hogs and whatever is appropriate to keep that room as clean as you can when that thing is taken. And then you clean it up if you do miss something.

All right, Building 3 is a very special one which we'll skip. And Building 4 is one that, all right, now we're actually making the connection.

How do we behave as we're actually making those connections in what we hope is a locally clean procedure? All right, first of all we wear bunny suits.

We do air monitoring in all cases, all right, just as if we were in a very clean clean room. And then we have an option, as it turns out.

This is sort of the result, all right, of using local clean rooms or using small off-shift work crews to make connections very quickly. And we refer to these two options as the "clean-room option," or the "fast-connection option."

All right, so there were more things that were considered beyond this one, but these are the two that survived the critique. All right, that if you have 5,000 class hours to work with, there's basically two ways you can get there.

You can get there -- They, this is exposure and this, you can do that with very clean air, having a lot of flexibility in the time that you use, or not so clean air but being very constrained as far as time that you're allowed to make this connection.

And here we are with the local clean room, or the fast-connection option. All right. Well, we have some familiarity with local clean rooms.

You've seen this picture many, multiple times. Every time somebody shows it to you they talk about something different.

I'm going to point out that this, this, this and this were all local clean rooms, okay? That's how the big parts in Beamlet were assembled, okay?

There's something else that I'd like to say in passing, is that when we choose things like Astro Pack to take our things over and clean them, that's a very good idea for assembly, but what happens if something gets constructed once you've already got it in the system? Well, then you're going -- Remember that isopropyl alcohol from a performance point of view.

The wipe-down works. From a cost point of view is more expensive, but if your tradeoff is taking that sucker off and hauling it over to Astro Pack, or putting guys in bunny suits doing a wipe-down, you're likely to putting guys in bunny suits doing a wipe-down over there to do a part of it, all right?

And that's exactly how Beamlet was cleaned for the big parts. All right.

So these clean rooms were used during connection and during the times that some of the parts in Beamlet were cleaned. All right.

Now, this data that I showed a moment ago about how room, how clean this room is, we've actually started taking that data last night as you left, right after you left, all right? And the reason we were taking that data was because we wanted to demonstrate something to you, which is that a place will clean up when there aren't very many people in it, and particularly if you have it wiped down well.

You can use these small crews to come in and then make your fast assembly checks, all right, in ways where you can take advantage of the fact that it was, room was cleaning up as you were absent.

All right, this particular room is part

of a wafer fab facility, but before it was fully qualified. This was still during the construction process, and this was at night.

It was about Class 200 at night, and during the day that facility was at approximately Class 50,000. This room has been running about Class 100,000 during the day, and no special filtering.

And the fact that it's fed from outside air and things like that, that, this is what happened to this room overnight, okay? And here's where it were when people were still walking around, and then here's where it went down at 1:00 o'clock this morning.

We think that probably what happened is there were some truck traffic outside of the building right here that kicked into the filtering system. Here we were.

We measured it this morning at 8:30 just as you came in, and it was back at 50,000. Okay, so, so we say, "Well, that fast tech-, tech-, fast connection technique can give us some flexibility. We wonder if we can really pull it off."

I've told you before that we have, we, sort of our experience was you could do it in less than an hour. This is how we gained that experience.

We didn't know that we could do it that fast, all right, and so we've put together a series of tests. We tested over a range, put four different tests in a facility called Amp Lab over a range of class-times-production, and I'll show you.

Here are guys in the bunny suits. Here's a piece being inserted.

This is just like one of those closures that I showed you before. Up here is one part of the beam path, or a replica of one part of the beam path, and a, a surrogate for another part of the beam path.

In this case you see it's got covers on. All right, we did it a number of ways, and so these are full-size closures, full-size NIF equipment, same size as NIF.

All right, we are in a space-constrained condition between here and here. We don't have much gap in order to get that guy in. We don't have much room around that area.

And we have one called "close-contact protocols." That is whenever a person is in close contact with this thing, how you will behave, all right?

And so we replicated those same

close-contact protocols. All right, here is what the room looked like, Amp Lab looked like.

This guy was sitting down on a lift, all right? And these are the two parts I showed you before.

We had everything in place. We were ready to go, and we had established the cleaning of this room by choice.

We had made it dirty or made it clean, whatever we wanted to do, because we wanted to test certain conditions, all right? And what we did then was lift it up and put it in place, put it into place.

All right, here it is going in. In some cases we took those covers off before we lifted it in place; in some cases we put it up and then we pulled the covers off after it was in place, all right?

And then also you might have guessed, this is what it looks like when you're done. Now, what are the advantages that we have because there were gaskets and because these were fairly snug-fitting connections, that once you have a couple of bolts in place, from the viewpoints of cleanliness, you're done.

Now you can take your leisure time in completing the bolts and completing the rest of this process. No more dirt is going to get in there once it's closed.

All right, what did we find out in these tests? We found out that doing it in less than an hour was reasonable.

We could do it a number a times, and we did it to an extent to many places. What we found in L-Tab, and we've found out that, that for the training that were --

THE CHAIR: Excuse me. How much training and experience does that require of the crew?

DR. SPAETH: Okay, these were our best technicians. We didn't take somebody off the street to do these tests, all right?

Although you could see, I went and watched a number of them, and I'd say, okay, asking exactly that question, "Could anybody be trained?" It takes conscientious people, all right?

It takes reasonably intelligent, conscientious people who listen and will be taught. There's nothing, you know, there's nothing sneaky about it.

You don't have to have years of experience at doing something like that, but you have to be a conscientious person. That's true, by the way, across the board for cleanliness.

Conscientious, you know, conscientious training is what you need almost more than anything else. You know, like, in the, in the, in, in, in, in the Apollo Program when they had a wrench in the door, you know, that wasn't what caused the problem, but unless some technician dropped that wrench and was too afraid to whatever, to admit he dropped that wrench.

All right, that's what we, you know, the thing that we have to impress upon these folks' mind is if you make a mistake, if your glove rips, you know, if something happens, tell us. We want to know.

We would much rather know now. That's, that's the, we want to know now. We can fix it now. If you don't tell us it will cost us much more.

DR. RICHTER: What do you do about it?

DR. SPAETH: What do we do about it?

DR. RICHTER: No, if somebody tells you, what do you do?

DR. SPAETH: We clean it again. Send

it back and clean it.

DR. RICHTER: Do you have in your bundles for assembly all of this factored into the time line, rework factored in and all the rest of it? Because that's the output of this whole thing that you're doing here, is what does it take to put this together?

And the people package alone, and how can you do in the program? So have you added in something for less than 100-percent success?

DR. SPAETH: I believe so. I surely believe so.

DR. RICHTER: As a systems engineer you know very well you have to.

DR. SPAETH: Oh, yes, I'm, we know very well we have to. You know, right now I would say the uncertainty is more in absolutely how much time does it take rather than how much contingency do we have to provide for these off-normal situations.

So, you know, we were actively, we're in a rebaselining program in the program heavy duty. That's what we do day after day one way or another.

DR. RICHTER: But you haven't finished this job and figuring out how long this is going to take.

DR. SPAETH: That's right. We have not. And that's what I'm going to tell you as we continue on.

DR. MOSES: I think there's one thing, though, this training issue. If we do go to Amp Lab and take a look, we intend to make this a training facility.

So you, it's full-sized. You can set up all kinds of conditions, as Mary is about to show, and it will be a part of our training activities.

THE CHAIR: Thank you.

DR. VOGT: In this assembly, this will not be done by your people, right? It will be done by contractors?

DR. SPAETH: Exactly how we do the contracting strategy is still to be defined.

DR. VOGT: It's still --

DR. SPAETH: I'd say in 95 percent of the options that are being done, this is done completely by contractors, quads by us. There's some situations where we have work teams, a combination of our own staff and contractors' work staff participating, working together.

I actually prefer the latter one. We'll see how it turns out.

In any case, conscientiousness and level of training is the important thing. It doesn't matter exactly who the name of that person is, or where he works, as long as he's a conscientious person and knows what he needs to do.

Okay, so then these were the results from the Amp Lab tests, all right? Also we found out that we could do these sequences in less than 40 minutes if we were very hype to, to understand, all right? And that we could maintain the surface cleanliness.

Holy smoke. If --

DR. WARLAUMONT: That's not too clean.

Red red: You could probably take it out of the sleeve.

DR. SPAETH: It doesn't have a sleeve. That's my writing. But I didn't write on this viewgraph.

This is, I, I wrote on something that was on top of it. I apologize.

DR. RICHTER: That was better than dirty.

DR. SPAETH: And they verified that the cleanliness could be maintained by eliminating kind of exposure. The kinds of classes that we've looked at were between a thousand and 10,000 and between 25,000 and 50,000.

All right. We deliberately set the room up in those kind of ranges.

The amount of time we had was on the order of 40 minutes, all right? And then we swiped the surfaces both before and after these tests, and we found out that when we stayed within our 5,000 class hours we had serious percent of the swipes that failed.

That is, they indicated surface levels was less than or equal to 100, and that when we exceeded those conditions, about ten-percent swipes failed. So that, that gives us actually a little bit, we were doing a little bit better than we expected, okay?

So it gives us a little bit more confidence than what we might otherwise have had, all right? So we look at those two options that rederived, which is the clean room connections or the fast connections, and said, "Okay, let's just look at how, what does this tell us about the constraints for what we want to do in the L-Tab?"

All right, we know if we use the clean room, the local clean room, we can have predictable, even clean air, and we think we can up to 50 hours of connection time. Well, well more than we need.

And we know we can do it any time of day. We don't have to do it in the middle of the night or the, on weekends.

All right, the disadvantage is those local clean rooms cost money. They're hard to move around.

You've got to pick them up, tote them over, and then we have to set them down. So it takes time and money to move them around, all right?

And we can't put a local clean room in every place. It's too hard to build.

We, our space is too jammed. If we do the fast connection, we know we can maintain our air at less than 5,000, and we won't do it if the class is worse than that.

It's cheaper, because we have much more flexibility in the space, all right? And, and, and you have more flexibility in actually making the connection.

You're not constrained by that clean room around you. All right? But now you've got to do it fast, and you can't leave that open, all right?

You probably have to have a small

opening through, and you want that conscientiousness here, all right? And so it's somewhat difficult to staff. And then you have to work at a particular time when you get those kind of local hours.

DR. RICHTER: There's a middle ground here, you know. You don't have to be all either open or local clean rooms.

Sort of plastic drapes and blowers with filters can give you a factor of two or three on relatively small things; --

DR. SPEATH: Yes.

DR. RICHTER: Not on your giant ones.

DR. SPAETH: Yes. Yeah, there is, is a space in between. There is, is a space in between our two areas.

I've lost them. What, what our goal is, 5,000 class hours. We can get it however we want.

DR. RICHTER: Uh-huh.

DR. SPAETH: You're absolutely right, all right? And I wouldn't say those are being neglected, but we're, I'd say we're trying to see where we can use these two first.

All right. So generally our strategy is the following, all right? Is we've noticed that clean rooms give you shift and connection time flexibility, and that fast connections give you location flexibility, all right?

And by the way, those clean rooms don't have to be around where the connection is. If you can have a nearby clean room and you can preassemble parts in that nearby clean room, that gives you an additional flexibility, all right?

So either with a clean room at the local connection plant, or a nearby clean room with the subassembly benches, we can benefit from a clean room and then use the fast connections when we need that kind of flexibility. So our strategy is to use a nearby clean room for subassembly whenever possible, because that beats all other options, all right; then to use the fast connection technique when and where we actually get it, the time and space allocations will make it possible, and use local clean rooms wherever possible.

And those local clean rooms can fall into whatever clean rooms. Some of those things where we have to, if you want the things we may be forced to use the kinds of things, because we can't get a really clean, clean room in them.

THE CHAIR: If you were *starting off

with a green field site and redoing your construction, are there constraints that are built in here that you could avoid? For example, --

DR. SPAETH: I think, I think -- We might have designed the space between bundles a little bit differently; given ourselves a little bit more room between bundles. We might have defined the space around some of the very difficult areas, like in the space frames or the target chamber, to give us a little bit more preassemble flexibility.

And we might have built in hooks to hold clean rooms, things like that. But we cannot get around the fact that the room basically looks like that, and you're not going to get a Class-100 clean room condition no matter what you do to a room that looks like that.

So the, the fundamental problem remains. We might have been able to make it a little bit easier for ourselves, but we wouldn't have been able to as easily escape the kind of, the kind of an analysis and planning that we're doing right now in any case.

Okay, so for those nearby clean rooms where they particularly work in the laser base, okay, we'll build a little temporary facility out here that will house a clean room, and we'll use Capacitor Bay Number 1 for, as a nearby clean room when we're doing work in Laser Bay Number 1. We like to -- This one has already got capacitors in it for Laser Bay Number 2, so it's not available.

Okay, so where are we in the status of planning for the beam path hardware assembly? Laser bay plans are getting relatively mature.

The biggest, the biggest open area is, is how do we use some of those local clean rooms, or do we use fast connections in some of the places? And I'll show you where those are.

And those are coordinated with our contracting strategy, so we can't really close on those until we've closed this contracting strategy issue.

All right, in the switchyard and in the target bay we are early in this process. I'll tell you a little bit about what's going on in there. And in plumbing and piping our plans are nearing completion.

Okay, so now I want to talk about the placement of the large vessels in the laser bay, all right? All right. If, if you're in the laser bay right now, what you see are the concrete pedestals, all the things that were normally planned in this picture.

The next step to complete we call "vessel placement," but it's a lot more, more than vessel placement, all right? It's all of the main structures that would hold up things, as well as the placement of the vessels.

Here's where those preamplifiers are that Ed talked to you about, located in a combination of here and here. There are the paps.

Here are the, the center vessel for the transport spatial filter. Here's a center vessel for the safety spatial filter.

Here's the region for the main amplifier. Here's the region for the other amplifier.

Here's L&M, the deformable mirrors. Here's what goes on in the next step.

All right, of these, the periscope, this here has to be assembled in the place. It weighs 160 tons.

It's too heavy for any transfer cranes to lift, so we have to bring it in parts that the cranes can lift and put it in place. It's going to be cleaned in situ with the means we've mentioned before.

All right, the FAUs, these guys, these guys will be cleaned in 381 and transported by clean-room vessels, and transported to wherever they go. All right, all the others are cleaned at Astro Pack, the facility nearby, with the soap-and-water cleaning system, all right?

And then everything will be protected by clean covers once they have gotten cleaned. Whether it's in situ cleaned, locally cleaned, wherever it is they'll be protected by these clean covers.

Then the next thing to put in is the vacuum beam tubes. We have, we have a nomenclature that sometimes is confusing to people.

If it has a vacuum in it, we've called beam tubes there. If it has normally atmospheric pressure, we call them enclosure, closure. Sorry.

Okay, so we will put -- These things are amenable to the subassembly technique process, okay? So they will be subassembled as much as possible and then brought into place.

If we can put them in place using the fast connection technique, we will. If we find that we're forced to use clean rooms, we will.

All right, once the, their subassemblies are put together again, protected with clean covers, moved close to the final position, and then put them together, right? And exactly the same thing is true of the closures, the things that have normal, normally the atmospheric pressure.

If you recall that picture that had all the arrows, there were any number of times when arrows were very close together. For the most part that represents that evenly though.

Looks like a relatively small structure, for whatever reason. There are a series of connections in that relatively small structure, so those connections would be made in the, the nearby clean room, then the whole unit brought and put into place, again with preference given to the fast-connection technique.

DR. RICHTER: How do you handle cleaning the utilities?

DR. SPAETH: Pardon me?

DR. RICHTER: How do you handle cleaning the utilities? You've got all these airflow systems.

They're going to be built. They're going to end up dirty. They have to be blown clean, checked before you hook them up to these closures.

DR. SPAETH: Okay, I didn't put in anything about, about plumbing and piping here, but let's talk about it for a minute. Tim Self, the, one of the guys that I showed you on that, in the people who are helping us from industry, has really got an incredible amount of experience, and we, we owe him a lot in helping us get through this process.

There's something that's called "oxygen service," which is a type of cleaning that people use for a lot of industrial installations. They, they, they clean them with solvents and then they actually blow a wad through them.

They, they put a wad of one of these low-particle-type things, put it in one end and put high-pressure air in it. It acts like a gun, and it shoots it out through this pipe.

And it, and it cleans, does a very good cleaning job as it goes, okay? So our intent is to buy that type of piping.

We are currently in the mode of testing to see how well it meets our spec. We feel confident that it meets our spec. for things beyond, before the filters can, okay?

All right, then we'll do, they'll,

these things will be pig welded. You fill the pipe with an argon atmosphere, do it, puts that little locally, welder around that, locally welds that in place. There's a lot of experience that that works very well, keeps it clean.

All right, for those areas beyond the filters, we'll clean those using a combination of a variety of techniques; some with Astro Pack, some with a variety of other gas cleaning techniques that have been used in the industry. But those are relatively small in size, all right?

So, because we've got, we want, we call them "point of view filters," we want to keep those filters as close by as possible to reduce the amount of piping that has to be very, very clean. Now, you also said something about, you know, those things are out there; they've been getting dirty.

Well, for the most part, these things have not been out there.

DR. RICHTER: They're installed dirty?

DR. SPAETH: It's the air-handling system fit that you described. All right, we were sending people into the air handling, the --

They're big enough, people can walk around in them. They'll be wiped down, all right?

And so they'll be wiped down to bring them to the level so that when we send the air into the building, that air will be clean.

THE CHAIR: Is this an appropriate place to take a break?

DR. SPAETH: It would be a fine time to take a break. And you'll find that you're going to get rid of me very quickly after the break.

THE CHAIR: Okay, we'll take a 15-minute break then. And after Mary is finished, we have time for public comments.

If anybody wishes to comment, please sign up. We welcome your comments.

(Whereupn, at 9:58 a.m. PT the Chair took a brief recess and returned at 10:26 a.m. PT, after which the following occurred:)

THE CHAIR: Perhaps we ought to reassemble.

DR. SPAETH: Okay, I'm going to finish off this description of what goes on with assembly in the, in the laser bay with the piping and plumbing.

We, maybe get the light, please?

A SPECTATOR: Sure.

DR. SPAETH: Thank you. We've talked a little bit about the piping and plumbing before, of, you know, how you clean and what you do.

And we break the pipe and plumbing into the region downstream of the filters and the region upstream of the filters, all right? So, do as much actual subassembly construction as we can of the pipes before they're installed, and then protect those pipes with covers, take them to the position, remove the covers, and install, as we spoke about, all right?

And then for the pipes upstream of the filters we don't have to do that local clean assembly. They can be dirty, and they can, the cleanliness as they come in is, is, we expect from the tests we've done so far indicate that they'll be just fine; all we have to do is install them.

All right, the Flange-to-Flange Working Group who has the responsibility of watching over this assembly activity has put together a, a manual, a preliminary manual -- It's still in draft form. -- for how these procedures should be done. And they'll be continuing that into the other regions, the target bay and the switchyards, as time goes on, all right?

And that manual has, has been a collaborative work of a lot of people; our industrial participation, every source who was kind of roaming around before showing people what damage looked like and answering questions as to the engineers who designed the system. It's been edited; reviewed many times.

Okay, so now we want to look at what's happening in the switchyard where we're just beginning to look at these issues. All right, the first thing we do is we put in space frames, and you saw picture of the space frames in the stuff Valerie sent to you.

The next thing is to put in a mirror support frame, the things which are turquoise-blue in this, in this picture, all right?

And subsequent to that we'll put in assemblies that hold mirrors LM4 and LM5. If you'll remember, as you leave the transport spatial filters, the first mirror it hits going toward the switchyard, pardon me, going toward the target chamber is LM4, and the next one is LM5.

Okay, these are all bows for those mirrors. All of these are protected by guillotine covers, all right?

So when an assembly comes in, it has half of the guillotine cover, and when its mating piece is put in it has the other half of the guillotine. And these two are coupled together, and the guillotine is withdrawn.

The plan is capturing the dirt in the middle, all right? This is a, this is a part of the lasers that some of our, our team that are part of the Jacobs Engineering organization that we have working with us, have been analyzing how this structure goes together.

Some of these vertical beam tubes consist of as many as three different pieces, pieces. We would like to do, as you've heard before, as much subassembly as we can, but this is so crowded that our current thinking is, and unless we figure out a way to do better, and this is part of the Jacobs analysis, is that we are going to have to put each one of these beam tubes in one-by-one.

And this is where a local clean room may be a very important part. You see where some of these beam tubes are vertical, all right?

This is the one situation, all right? Stuff can fall right in.

All right, in the target building we have the target chamber in place. All right. The next thing to do is to put the mirror support frames around the, around on the, the, the target chamber.

And because of the way the targets come in, or the beams come into the target, they're located at these locations. These have guillotine covers in the similar fashion, and then put in the target area closures.

And once again we're looking to do as much preassembly as possible, but finding it difficult to do as much as we would like. All right.

And then the last thing to go in is the final optic assemblies. There is a special region of this beam tube which can be collapsed, all right?

These parts, they pull back in order to make space for the FAUs, pardon me, for the FOAs to go in, and then they're unretracted and the final attachment is made.

DR. VOGT: Is there a flexible?

DR. SPAETH: I'm sorry?

DR. VOGT: Is there a flexible?

DR. SPAETH: I'm sorry. It's a flexible coupling, right; a belt.

Okay, so in summary about this beam path assembly is that our focus for the past three or four or five months has been on the laser bay, and for the most part we're feeling fairly comfortable with that, with the final details as I described, and with working with a contracting strategy. And we're moving to the switchyard and target bay, putting our attention there now.

DR. VOGT: Do you have any industry involvement in these time and motion studies in there?

DR. SPAETH: Yes. As a matter of fact, of fact, a couple of people -- I'm not sure exactly what's happening with the status of the tours, but I know that the plan is to have Don Wadkins and Vern LaFavre, both of those, one of those is from, and Vern LaFavre is the satellite diner/builder/ transporter, both of those guys have been totally involved in, in, in those studies, and then, in fact, are going to be on the tour to answer any of those questions you might have when you're there.

Okay, so now the, the next thing to talk about is the final step. Back of those NIF concepts of now we put that sucker together.

Now let's talk a little bit about, more about the hardware that's involved in finally putting it all together, all right? And it says, "Okay, how do you install clean LRUs in a clean bathroom, -- Clean bathroom. Something I'm always hoping is for, clean bathrooms. -- in a clean beam path through a dirty room, and, and, and it says, "You employ the <smich> block concept of refrigerator scale."

But I must point out that this is industry refrigerator scale. These are not home refrigerator scales, okay?

And so just to remind you how many LRUs that we have to deal with, all right, there are more than 3,000 of these big ones, and then there are any number of the smaller ones, all right, that still have the same delivery character. They are all over the system.

It is the whole strategy for how NIF is put together. I, I, I, I, I think there have been conversations about: How can you do assembly and operation at the same time?

Assemble a later part of the system while you're operating an earlier part of the system. Following this concept to maintain cleanliness probably gives you as much flexibility as you can get from any other way to put this system together, all right?

The current plan or baseline plan is, insofar as the plan lives up to its current thinking, is that we would do this on one shift, the first shift of the day. So, if we were to try to operate in a mode where we would do both assembly and operations, we could add another shift to, to, to allow us to do more, have more flexibility for additional assembly activities, and because you have, this whole thing is basically constructed when you're doing it.

What you're doing is then just driving those little vehicles around and putting them in place. It's relatively not disturbing of the surrounding region, so I think that although we, we follow this approach because of its cleanliness benefits, I think it has benefits also in flexibility to doing concurrent construction and operation.

Okay, the, this gives you a little bit more of a breakout of the spaces where those LRUs were constructed. This is the OAB.

There's other work being done in OPDL. Stuff that's been done in OPDL is brought in here.

We do gross mechanical cleaning in that Class 1,000 room. This is where we do the final precision and cleaning, bag it, and put it in air lock and take it over here in the Class 100 spaces.

And then we drop it through the hole in the floor in the mini-clean room and deliver it to the beam line. Where we are in that facility is right now we're in the certification phase.

This is the, a view, a recent view of the Class 100 clean room. This is what it looks like from the outside.

So, we have about 8,000 feet Class 100. The rest of the building is either Class 1,000 or Class 10,000, or not rated at all; that is, an ordinary space.

And I think that you saw, here's a, a combination of pictures that this is going into the elevator below. This is a transit through the beam line, holding one of the canisters for delivery; and then this is an artist's concept of what it will look like when it actually is going into place, putting something into the beam line.

Here's a photograph of the transporter with the bottom-loading canister being carried on it. I think you saw this on your tour, all right?

So, tests are continuing to go. I drove it last week.

That was a great deal of fun. I don't drive it nearly as well as its computer drives itself, but it can be driven manually.

And that's pretty much what I have to say to you about cleanliness, all right? I guess that I would like to say that as we have proceeded in a path of building ever more capable ICF laser systems, we've also been growing in our understanding of what it takes to keep things clean.

We didn't know about NVRs back here. We didn't know about a lot of the ways that particles are formed in this system until we got into this regime out here in time.

We're taking Nova apart very, very carefully right now. We, we have nearly got it apart.

We're recording all kinds of things as we take it apart, and we continue to gain insights about cleanliness. My view is Nova was a, a cleanliness experiment that ran for 18 years, and what's left for us to do is just to take the data as we take it apart.

And so we're doing that, and we're learning a lot about what the sources are of cleanliness. Is vibration an important source?

Is vibration an important source of when that shot fires, that glass moves. As that glass moves, does it knock off a little piece?

You know, that continues to increase. And what those sources, they continue to ameliorate the sources of damage. And one thing I'd like to say is even though we're understanding a lot more in where the contamination can come from, and how to, how to keep it out of our lives, the sensitivity to the importance of cleanliness has not really changed from the very early days.

We have always been very sensitive to knowing that it was very important to have this place clean. So here's my last viewgraph, is that you know we've had a history of working these kind of problems and developing and delivering systems that have operated for many, many years.

All right, NIF has been designed with this knowledge and with all the concepts that we've designed over the years in how it ought to work when it's there. And our problem, or the, the issues that we've been facing most recently is understanding and selecting those techniques that we have to use for this clean assembly and the close-packed configurations of, of NIF.

And this is the work that we still have to do, okay? Refine and finalize all our plans for beam path and utilities connection based on the status you've heard from today; very importantly, develop and, and, and complete these training programs, and look for these conscientious guys who can do it, put it together right; actually do it all right; and then work through the sort of procedure so we don't destroy that sort of cleanliness we've worked so hard to get in the first place.

THE CHAIR: Thank you.

Any comments?

DR. BYER: What sort of -- When you talked about training, and I was wondering what sort of resource base in terms of people will it be, do you think will be required to accomplish this list? Could you speak about training programs and what --

DR. SPAETH: Okay. Well, if you look and you say we have to do 180 connections per, no, you're probably going to have to have teams, somewhere between one and four teams, all right? And some, some of those teams will be doing preassembly, some of those teams will be actually on the floor actually doing assembly.

I would guess that a team is going to have somewhere between ten and 20 people on it, you know, with, and some of those, those team members are going to be getting it ready. You want to have the minimum number of people around when you're actually doing the connection, but you also have to do activities to get it ready to make the connections that are not so clean.

So, during the day before it's very clean, you get everything in its place. You have a check list.

You make sure that this, that, that, and the other, and then when you're actually doing the fast connection on the off-shift time, or whatever it is, all right, you would have a team then, I would guess between five and ten people who are actually doing that thing, putting it in place, getting those first four bolts in.

Okay, once those first four bolts are in, you're fine. You can do whatever you'd like again.

THE CHAIR: Gail?

DR. McCARTHY: Yes, I'd like to ask maybe on this viewgraph, I don't suppose it matters much, but if there is a mishap on one of the flange, the flange connections, and contamination gets into the beam path, how far could it propagate?

DR. SPAETH: How far could it propagate? Okay, so I'm looking, looking for that chart which was a picture of -- Here we go. This is one, the one I'm looking for.

Okay, this is a drawing of the beam path up to the switchyard, all right? So, every place you have a cavity spatial filter you have a closed beam, all right?

So, the space which is open, first of all, the bundles do not connect to each other. A bundle is open to itself in general, but the bundles, but not always, and the bundles don't connect to each other except in one place.

Okay, so there is no bundle-to-bundle connection in here, all right? So anything that can go between LM1 and this, A and the cavity spatial filter, could have a problem.

Anyone goes from this end of the cavity spatial filter out to this cavity spatial filter, I'm not sure that you can get past that. It might be closed.

You may not be able to get past that spatial. I'm not so sure how tightly this is closed, so this may be, this may be the other one, would be from here up to here.

And then from this cavity spatial filter you would go -- And there are ports. There, there's something called a "roving mirror assembly" which is on the big wall as you go into the switchyard.

There are ports there. Depending on whether or not those ports were open, depending whether or not they would mix it at the roving mirror, the bundles in a, in a cluster share each other, so it could get around if it happens there.

Then once you get beyond the roving mirror into the beam tubes, those are all individual beam tubes again up until you get to the target chamber.

DR. McCARTHY: So if there is a mishap, you know, what volume would you actually need to go in and clean out?

DR. SPAETH: Well, it depends on what kind of a mishap you would have, of course.

DR. McCARTHY: Right.

DR. SPAETH: The kinds of things -- Let's just think of diversity. Let's think of the kinds of things that, God forbid, you'd not like to think about, okay?

One of these, one of these implodes. Okay, well that would make a mess.

You would have a lot of cleaning to do. A lot of it you would have to take stuff off of there, clean it off-line, and bring it back in.

Okay, we've got layers of things built into the design to keep that from happening. The thickness of the glass is chosen that it will not crush on itself.

All right, we have diagnostic systems that look for the damage locations that would allow it, and we have diagnostics systems of things that would, causes that to happen. So there's multiple layers to avoid that from happening, another thing that could happen, another thing.

DR. MOSES: But that would be in the operational mode, not in a building mode.

DR. SPAETH: That's correct. That's correct. And another thing that could happen, and in fact not could happen, another thing that will happen is that a flashlamp can explode, all right?

And there's just no question that that will happen. Happens all the time. I mean, not every day, but we've experienced it.

There's no way we know of to stop it from happening. All right, so what we have done there is to put limiting resistors in the path of the flashlamp to limit the amount of energy that can be deposited in that flashlamp.

And we have tested whether or not that

amount of energy can break the blast shield. So we are several factors, safety factors away from the amount of energy that can be deposited in a flashlamp explosion compared to what can break the blast shield, so we don't think that we're going to break a blast shield.

All right, if you do break a blast shield for whatever reason, then you have penetrated into that bundle region where the flat, the slabs are, and again, now you've got a big cleanup.

What else could happen? You know, you can damage a surface and you'd have had to -- Most the time the, the kind of things you're more likely -- I gave you the worst-case-scenario kinds of things.

The kind of things that you are more likely to experience are you'd have some damage that diagnostics would find it, layers of diagnostics we've not talked about. You'd find it maybe here, maybe on one of these mirrors.

You'd find the, the amount of residue that that would leave would be very small. You'd just exchange it.

Like, it wouldn't require removing equipment, going in with bunny suits, or anything like that. In the big vessels you can go in with bunny suits. In the beam tubes you probably have to take them out and clean them.

THE CHAIR: Okay?

DR. RICHTER: I have one which is not cleanliness question, but a, to you as in charge of Systems Engineering. Has anybody taken a look at the impact of starting to do physics before all of the beam lines were completed?

You've alluded to it briefly toward the end of your talk, but the ultimate goal is 192 beam lines. You clearly don't need all of those to start the science program of the NIF, but if you start the science program, say, halfway or a-third of, third of the way along, then you've got operations and installation going on in parallel.

They have to have impact on each other. Have you had a chance to take a look at what that impact might be?

DR. SPAETH: I think that probably two people should answer that question, Ed and I. Ed has really looked at those things that are related to the benefits of doing what you've just said. And in fact it's part of our strategy, all right?

As far --

DR. RICHTER: Well, not part of your original strategy. Original strategy, the whole thing was supposed to be finished July first.

DR. MOSES: No, no, no, not even close. It was always part of it, the strategy, to do physics while you were turning it on, the way it was being turned on.

You were turning on Laser Bay 1 and then Laser Bay 2 over a couple of, over a two-year time period. Now, I think there were some differences with that theory of how it would run.

I think with this infrastructure first strategy, where you have the whole facility operational and now the physics, the users' community decides what budgets they want, excuse me, what budgets they want in what order, and when they want them, is, gives all the flexibility that could have in theory.

I think the issues that have to be resolved and found out are, you know: Will there be any interaction as you're loading up LRUs, you know, among mounts?

According to all our calculations there are none. I mean, it, it should be sensitive enough, and everything is there.

You should be able to load it up, and nothing is there so that you could, in theory. And I think it will end up in practice, be able to do loading the system and running the system simultaneously.

DR. RICHTER: Well, clearly I think for safety reasons you're not going to do four shots a day and be running two shifts assembling new systems. The original plan, if I remember it right, was that you finished one side of the whole facility, started to use it, and then you assembled the other side where there were no interactions.

The users now seem to want more symmetry, which says you're going to have lasers firing in the whole system, and you're going to continue to do installation all over. So there will be working lasers right next to places where you're going to be installing new ones.

And, and that's the question I have. It's a different strategy than the earlier one of starting to do asymmetric experiments.

DR. MOSES: But, but just to say this, even the, in the earlier one, the whole idea that you were going to have instantaneously two laser bay, a laser bay, or two clusters loaded up at once, and not have done anything until you did, I think is not really how life would have developed. I think there will always be a situation that once you get a bundle in, there will be time.

As I was saying last night, there will be time when people want to use that laser. And there are safety issues.

There will be time when you cannot be in the laser bay during a shot for electrical reasons, for one. And so I think it fits the most natural way with the ultimate flexibility.

It won't be always -- You know, reality will always be there. You have to be safe.

You have to clear the area during a shot. You can't be there right after a shot until the safety system is safed out, the vacuum system is safed out.

It's also true that the first part of the laser's first strategy just uses Cluster 4, so that means that you do have Cluster 1, Cluster 3, Cluster 2 that are available to you before, before you really have close coupling of cystometry.

DAVID: The biggest fundamental, training, you didn't make strong enough comment about; was doing the infrastructure first, whereas, you were doing the infrastructure while 2 was --

DR. MOSES: I actually think the other way was the unsafe way. Very difficult to do for -- Impossible in reality.

It was very difficult to put the system together, and now you have, with this method you have, you take the trades and separate them out from the user community. And you also now can now control access of, you know, the installation and operational world from the, from the target physics world in a way that's appropriate.

I think this is really much more flexible, much more safe, and will meet the needs of the user community earlier than rather than later.

DAVID: The, the whole philosophy and the strategy was that you would always be able to do line replaceable units inter-, interleaved with operational units. There might be a question about how much when you're trying to assemble it, but the, the original plan said we're going to swear, leave infrastructure installation, and that's what Ed decided wasn't acceptable.

DR. MOSES: By the way, there is a precedent on this site for doing this, you know, which is the last laser system where you actually were running the laser system 24 hours a day for years, many years and, and replacing worn out parts the whole time. And that went on for over ten years.

DR. RICHTER: You're doing a new baseline now, and somehow in this new baseline you're going to factor, have to factor in construction time. And I can't see you putting as many lasers per month into operation once you start operating for research as you did before.

DR. SPAETH: I think you've --

DR. MOSES: I think -- Just let me say one other thing. Just so you know this in -- Lloyd, you showed the number of shots that were going on that were four joules per square centimeter, and maybe something you'd like to have is a conversation, a more detailed conversation on this.

That includes all the acceptance tests and the operational tests of the laser system were scheduled into those number of shots already, and fairly carefully. So I think that, you know, I think we have thought about that.

I think it needs to be somewhat more peer reviewed than it has been, but it has been included in a schedule already.

DR. VOGT: What's a realistic number of

shots which you should take into consideration in the early time, and what limits it? What, what, where actually is the target preparation which limits the number of shots, or what --?

DR. MOSES: Well, early timing is hard, you know. Life is hard to predict, but I think that the facility has, the laser facility, like a single beamline, has approximately now a four- to eight-hour cycle time, and that's for the glass to cool down and come, you know.

DR. VOGT: Is that the limiting factor, or the target preparation?

DR. MOSES: Well, I can't speak for the target preparation, but I think that will be a limiting factor. But I'm saying that I think you also have to remember that, that there are a lot of beamlines in, in NIF.

You don't have to accept the times. We were firing many of them at once.

You could be firing shots quite often. You know, you could fire these set, this symmetry set or that symmetry set. If they could put targets in quickly, you could go through --

DR. VOGT: Ja-Ja, but I'm saying where, but the target preparation of that scenario is not yet worked.

DR. RICHTER: Well, I think the target turnaround time would be something like one hour. You might be thinking about cryogenic types, which would be completely different, but most of the targets shot would be targets which are analogous to the targets we shoot on Nova, although more complicated.

And the alignment time for the targets, and the time to recycle the diagnostics would be similar to Nova, which is about one hour.

DR. VOGT: Thank you.

DR. SPAETH: I'd like to talk a little bit about, more about the choke points in the system. You know, what is it that would limit it?

First of all, the word that you use is "construction" of the lasers. I think that the word "construction" is a little misleading. The construction itself is completed.

DR. RICHTER: Installation. I'll be happy to stand corrected.

DR. SPAETH: Installation. It's the installation, and that installation is -- Ed and I both worked on that the last system. You know, we, we actually were the architects of, of how that refurbishment and assembly strategy occurred in that system, okay, so we have thought very much about this kind of event.

In that system we had a combination of numbers that fit, and we could say that assembly and refurbishment were identical. You could not tell what a person was doing, whether he was refurbishing a, an old laser or building a new one.

It was a continuous process. We've tried to take that philosophy and put it into NIF as far as NIF can accept it with the decisions that have already been made.

You can't make it, quite; not because of the way it was strategized in the first place, but because the numbers turn out a little bit different for NIF than for Atlas. But basically the choke points is we have a single shift using all of these, and the number of transporters that we have to deliver them.

They take a certain amount of time. They drive slowly so they don't hit anything, and they have a certain amount of time to purge the gases in them so that their gas matches the gas that they're going into it.

We have a certain amount of time

between shots for diagnosing whether or not there is something damaging about that system, so someone can go into that area and actually be present in that room where you have to.

Those are the kinds of things that choke us. And we were -- Storage is another choke point, but when you have empty, when you have empty lines, you have storage, because if you've got an empty line, you've got a place to put it.

So, you can put, you can be assembling stuff, stuff that you wouldn't be wanting to put in a line right away, but you have a place to store it. So you take all of those things, the combination of, you know, adding shifts, adding transporters, using the storage that you already have built in, and minimizing the diagnostics time to tell whether the facility is safe for people to enter.

It gives you a lot of flexibility, and, and, and you're not as concerned as you might first think.

DR. MOSES: And, and --

DR. SPAETH: I think you can do a lot of this in parallel.

DR. MOSES: Yeah. And again, I think that the present strategy is to do Cluster 4 first, you know, for the sterile weapons experiments, you know. Really gives you at least a year of more flexibility in Clusters 1, 2, and 3, where you can add, really be separate to first order; especially in Clusters 1 and 2. You're in a separate facility completely.

DR. VOGT: Am I correct in assuming that the Operations staff and the, the Assembly staff is different people?

DR. MOSES: Well, actually this whole transition plan thing which I've talked about a little bit, you know, the last time, is sort of a fundamental question that has to be resolved. I don't think --

And, you know, I wasn't, I'm only speaking personally now, that the Assembly staff and the Operations staff are very separate. I think they are.

But then when you talk to the target physics community, they have a different point of view, which is, "We want to have an Operations staff that will be in the mission support operation that will define the experimenting carefully and will hand off, you know, what experiments, how they want the facility configured."

But the Operation staff that will be running the laser, and the Assembly staff, sort of very, managed from a single place in that assembly integration refurbishment, Operations Group. I think it's crucial that that happens.

DR. SPAETH: But it's true that they are, have a single manager and they are very well-integrated, but you do have separate people.

DR. VOGT: That was my question.

DR. MOSES: I'm sorry.

DR. VOGT: Because otherwise you'd have a conflict.

DR. MOSES: Right. Right. I think the, the story of NIF, like Nova, is that you really have to have well-defined experiments

And, you know, Joseph Kilkenny and the Weapons people are thinking about those things now so that the facility can be configured to run those experiments off-line. And I think this strategy gives them the most flexibility possible.

THE CHAIR: Any other comments or questions?

DR. McCARTHY: Just a question. Could you just tell us a little bit about what the quality control for the cleanliness and contamination is like in case of damage for the system?

DR. SPAETH: Okay, there are, there's a number of different layers of that, all right? One of the things that is very well-developed is the contamination, pardon me, the quality control tasks that are associated with having the contractors come in.

The, you know, the contractors are very used -- They have quality control for everything they do. So, a large part of it is an extension of whatever it is that those folks do, all right, in their normal operations, but adapted to our particular units of measurement. And so it's not a substantial change from what they're very familiar with.

Another element of that is that, that we have a, we, we're developing something called a "master test plan," which is, includes a lot more than just what you might consider as normal testing, but as the testing of the whole laser as it, as it comes up, all right? And so that will have built into it, you know, a program test of cleanliness issues whenever it's appropriate to do that, all right?

And, and in developing any of these, we

have a matrix of people who are in the, who are working in the area of putting contracts and doing that kind of work, you know, the interface with the outside world, bringing people in. And the people who are the LRU owners, the system managers, the people who have had that, the detailed technical knowledge of what each one of these systems requires, as well as every source who was roaming around before and his staff, okay?

So there is a system for cross-checking, that whatever the quality control procedures that are written have the opportunity to be tested by, by the folks who have all the years of experience in, in saying what it ought to be. And then I still would like to see a combined -- And I don't have this -- This is not true, but I feel strongly that it's something that's important.

Like to see some kind of coordination, some kind of collaboration, coordinated effort between our long-time technicians, our senior guys who really know what it takes to put something like this together, and those technicians who are actually going to be doing a lot of the work that come probably from some contractor's house.

So, you know, it will be realtime,

on-line watching it, as well as all of the written procedures that, that, that you have in place.

DR. VOGT: But isn't that a quality control function?

DR. SPAETH: Yep, but it's easy to forget sometimes that that function cannot be relinquished by you, yourself.

THE CHAIR: Other questions or comments? (11:00 a.m. PT)

(Whereupon, no response was had.)

THE CHAIR: Thank you very much.

PUBLIC COMMENTS

THE CHAIR: We've now come up to the, the time for public comments. The first comment, the first person who signed up is Marilyea Kelley.

You have five minutes, please.

MS. KELLEY: Thank you. Hello again. I'm Marilyea Kelley, Extensive Director of Tri-Valley CARES here in Livermore, a position that I've held for 16 years.

And as you know, we've been analyzing and investigating and researching the National Ignition Facility since end of '93, beginning of '94, and our record on it begins with a March, 1994, letter to then Energy Secretary Hazel O'Leary recommending that KD1 be postponed, which she did for a short time.

And one of the things that we've been looking into from the beginning is the issue of technical readiness. I spoke about some of the technical problems in my brief time before, and listed ten.

Some of them have been talked about here, and, but some of them I haven't heard talked about here yet, from things like the diffraction grading, or the sol-gel problem there, to the, some of the final alignment problems with the beam. So, I, I believe the silver coating problem did come up, as well as some of the others.

There are some additional diagnostic problems, additional target fabrication problems, and even the methodology to place the target in the chamber. And what I recommended when I talked about those, as well as the damage propagation and the continuous-power and some of the other problems that have been discussed is that our assessment is this is really a series of R&D projects, and some of them are in the R phase almost, and that it is, is not a project where construction funds should have been expended, and it is not a project, based on my best analysis, where expending additional funds now to continue with construction while you continue with R&D to try to resolve these problems is likely to result in a working laser at the end of the road.

By "working laser," I want to define it as a laser that would have even a ghost of a chance of achieving its scientific goal of ignition. What you're likely to get is a laser that doesn't achieve ignition, that may actually cost closer to $10 billion over its lifetime than the $5 billion currently estimated, and which is useful only to a narrow cadre of nuclear weapons facilities to advance nuclear tonnage in a narrow area not necessarily needed to maintain the existing nuclear arsenal. There's your danger.

A couple of other things I'd like to sort of touch upon. One is that in your charge, in terms of advising the Secretary, in addition to flagging these technical problems as needing more analysis, I would strongly recommend that you flag for the Secretary that ignition on NIF may in fact be a pipe dream.

Many physicists gave NIF a five- to ten-percent chance of ignition back in 1995, before the extent of these problems became known. With the various individual and multiple problems along the beam path, with the beam itself, with the optics, with reflection, et cetera, et cetera, et cetera, it is becoming clearer and clearer that anything glass is highly, highly, highly unlikely, and I think that the Secretary should have that brought to his attention, and it should factor in decision-making.

I also, even though this is a bit radical, and I think you can tell from what I said, recommended that at least be discussed with the Secretary the idea of the Department of Energy, Energy supporting a halt in construction in front of Congress while the R&D is, is looked at, and especially a halt while the full costs of the project are analyzed.

And in that vein I give one example. The first series of meetings that I attended, you may recall that the Laboratory proposed solving the homogeneity problems in the laser glass slabs by an extensive grinding of the glass to recant imperfections that basically obviate the ones that are in the glass. And I asked --

One thing about living in Livermore is there are no shortage of optics experts living in town, so I asked folks, "Is this feasible?"

And I don't have a fine word. I mean, I always heard "maybe," "very difficult," but at a minimum, that you need to shave it and then you need to -- I think the word was "equilibrium."

You need to actually keep it at a very steady temperature for 24 hours and retest. And that, each laser slab would have to go through that several times.

So, each laser slab, to even find out if it could meet spec., could take days or a week. And then you look at the fact that 3,000 of them are proposed, that a certain amount won't meet spec. after they've been ground, and you have the, all these other issues, and you do the math in terms of amount money and amount of time, that some of these things aren't computing unless you give NIF the whole national treasury and the next century.

So, I strongly recommend that this Task Force ask some very serious questions about how much money is it going to cost to potentially solve some of these problems.

A final thing, I did not find out about this series of meetings actually until I glanced at my Sunday paper, and therefore I'd, I was unable to completely clear my schedule to attend all of the time today and yesterday. And if you would give more timely notice of when you are coming out here, that would really help those of us in the public to attend fully.

And I hesitate to comment, too, since you could have sea-breezed through here without having any particular public hearing at all, but unless -- I'd like that to be taken under advisement by the Panel.

And if I have a minute, I'd like to talk about some deficiencies in that UC report. Their charge included looking at the technical difficulties, and the first and most striking thing I noticed in reading through the report is that they did not do so at all.

That's deficiencies that simply cannot be overcome. You have a whole series of panels that isn't looking at the most obvious thing, and so I'm having a lot of faith and some confidence that this panel will remedy that situation.

The UC Committee did not. And while they were very harsh regarding some of their management criticisms, the final line that they seemed to be attempting to come to was that if you just made some management changes and gave it some more money, that everything would be all right in the end.

And as I say, employees have been telling us for some time now that that's simply not true. And if the Secretary were to proceed on that assumption, he would be putting the credibility of the entire Department of Energy at risk. Thank you.

THE CHAIR: Thank you.

Is there any, anyone else who wishes to make comment?

(Whereupon, no response was had.)

THE CHAIR: If not, I guess we are adjourned. And for your information, our next meeting is --

MS. MULLINS: December thirteenth.

THE CHAIR: -- December thirteenth.

Thank you all very much.

(Whereupon, at 11:11 a.m. PT the above hearing was concluded.)

I certify the foregoing to be a true transcript from my notes.

____

CSR, CP, RPR

CERTIFICATION

I, Dorothy I. Bunn, a Registered Professional Reporter, Certified Conference Reporter, and Notary Public, do hereby certify that the foregoing testimony was duly taken and reduced to writing before me at the place and time therein mentioned. I further certify that I am neither related to any of the parties by blood or marriage, nor do I have any interest in the outcome of the above matter.

In witness whereof, I have hereunto set my hand and affixed my official seal, at Livermore, USA, this 30th day of November, 1999.

____

Notary Public

My Commission expires November 17, 2003.

A P P E N D I X

LETTERHEAD:

Secretary of Energy Advisory Board

Washington, DC 20585

November 24, 1999

TO: MEMBERS OF THE NIF LASER SYSTEM TASK FORCE

FR: BETSY MULLINS

EXECUTIVE DIRECTOR

RE: ADDITIONAL WRITTEN PUBLIC COMMENT

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As you know, the NIF Task Force is chartered under the Federal Advisory Commission Act and, accordingly, welcomes public comment. Although meeting agendas include time for public comments, some members of the public may be unable to make comments during that time and are welcome to submit written comments for the record.

Attached please find, for your review, written comments signed by four officials from the Natural Resources Defense Council; a professor of Nuclear Engineering at the University of California; and a retired Engineer from Lawrence Livermore National Lab.

These written comments also will be enetered into the transcript as part of this week's meeting and, therefore, will be available in the Department of Energy's Freedom of Information Public Reading Room.

Thank you for your attention to this matter.

LETTERHEAD:
Natural Resources Defense Council

The Secretary of Energy Advisory Board
National Ignition Facility Laser System Task Force
Members: John P. McTague (CHaiman)
Andrew Athy (CHairman, SEAB)
Robert Byer
Gail McCarthy
Lawrence Papay
Burton Richter
Rochus Vogt
John Warlaumont
c/o Betsy Mullins, Executive Director, SEAB
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

November 17, 1999

Members of the NIF Laser System Task Force:

On behalf of the Natural Resources Defense Countil, Inc. (NRDC), we are submitting written comments to the Secretary of Energy Advisory Board National Ignition Facility Laser System Task Force (herein referred to as the "SEAB NIF Task Force"). The Secretary of Energy has requested that the SEAB NIF Task Force consider "at a minimum: the engneering viability of the proposed assembly and activation method; the assembly and installation cleanliness protocols; the management structure; and the adequacy of the cost estimating methodology." The National Ignition Facilty (NIF) project is troubled by a number of significant technical problems in addition to the problem of clean room status. Because these additional problems facing the NIF project are outside the minimum Terms of Reference, reocmmendations based solely on these minimum Terms of Reference cannot serve as an adequate basis for advising the Secretary on the future of the NIF project.

Four problems facing the NIF project in addition to clean room issues are in the areas of: 1) amplifier glass fabrication; 2) anti-reflective optical coatings; 3) spatial filtrs; and 4) ignition target fabrication.

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11-17-1999 6:02 PM FROM NRDC WASHINGTON 202 289 0990

NRDC COMMENTS TO THE SEAB NIF TASK FORCE

NOVEMBER 17, 1999

1) Laser Amplifier Glass: The Schott company with manufacturing facilities in Pennsylvania and the Hoya company in California are currently contracted to fabricate the large slabs of amplifier glass for the NIF project. Schott and Hoya also fabricated the amplifier glass for NIF's predecessor facility, Nova. The initial operating experience from Nova indicated that platinum inclusions in the glass were at an unacceptably high density, and the effect was that Nova could not run at the planned energy fluence. Subsequently, Schott and Hoya improved the glass fabrication technique for Nova which involved a slow, cooling/conditioning process after the glass was poured.

This amplifier glass fabrication technique demonstrated on Nova is not planned for the NIF because it would be too costly and time-consuming for the NIF's greater glass requirements. Rather, the NIF project entails an exploratory glass fabrication technique called "continuous-melting" or "continuous-pouring." LLNL first gave Schott and Hoya moneys to build prototype laser glass factories, to let them compete and see which one did a better job. Neither prototype factory produced glass meeting all of the NIF specifications, but both companies assured LLNL that they understood the problems and could fix them. With those contractor promises, and Livermore's concerns with the time deadlines for NIF amplifier glass production, LLNL authorized Schott and Hoya to proceed with building of the full scale factories.

Last fiscal year the first batches of full-sized NIF amplifier glass were delivered and found to be below specifications for a number of reasons: platinum inclusions, volume inhomogeneities, surface ripples and water content. Importantly, the full scale glass factories as well as the prototypes have not produced laser amplifier glass meeting NIF specifications. Schott and Hoya have now reassured LLNL that they understand the probems, and they will be fixed soon. Nevertheless, Livermore can not state at this time that the NIF amplifier glass can be delivered either on time or on budget. There are serious doubts about whether or not continuous-melting will in the end be a viable approach for fabricating these crucial NIF components. If Livermore is forced to return to the older glass pouring techniques used for the Nova laser, the time delays and cost increases in the NIF will be far greater than anything yet considered.

2) Anti-Reflective Optical Coatings: Much has been achieved in the raising the damage threshold of optical coatings at Livermore. Nevertheless, the NIF is pushing the technology and new difficulties can and did arise. Anti-relfective optical coatings are necessary to prevent laser energy losses and to protect the optics components from high-fluence damage. Currently problems persist with the anti-relfective coating on the frequency-tripling potassium dihydrogren phosphate (KDP) crystals and with the anti-reflective coating on the diffraction grating which steers the lw- and 2w-light out of the target chamber. These are crucial issues for the performance of the NIF, and it could mean that each of the NIF beam lines will only be able to produce a small fraction of their design energy at 3w.

3) Spatial Filters: Livermore has calculated that ignition can only be achieved at the NIF using a long pulse: 20 nsec in total with about a 3 nsec high intensity component. In order to accommodate such a long pulse, the NIF spatial filters must stay open for about 20 nsec. LLNL

claims to have devised a means to keep NIF's spatial filters open for the required 20 nsec, but this solution was never fully tested on the prototype Beamlet laser.

4) Ignition Target Fabrication: The original LLNL ignition target "point design" had a plastic ablator surrounding the fusion fuel. This design required significant research and development in the area of cryogenics. Around 1996-1997 the plastic ablator design was abandoned because further calculations at LLNL showed that -- for realistic targets -- the plastic would mix with the fusion fuel as the target imploded to such an extent that the mixing would prevent ignition. When this was realized, Livermore managers diverted funds and manpower out of the cryogenic target program. It appears that the programmatic shift away from cryogenic plastic targets was never aligned with overall project management and cost accounting, however, nor fully explained to the cognizant oversight committees in Congress.

The next idea for an ignition target, widely discussed at the 1997 American Physical Society's Division of Plasma Physics Annual Meeting in Pittsburgh, PA, was to use beryllium as the ablator material. Beryllium ignition targets have the advantages over plastic targets that: 1) the ablation rate is higher, reducing the rate of mixing with fusion fuel during implosion; and 2) the material strength of beryllium is such that the required amount of deuterium-tritium gas can be held at room temperature. Beryllium target fabrication research is largely conducted at Los Alamos National Laboratory. It now appears that beryllium cannot be used as an ablator due to the fact that welding the two beryllium hemispheres together produces a weld line which interferes with the strict requirements for spherical symmetry in the target capsule.

The situation facing the National Ignition Facility today is that, after more than half a billion dollars appropriated, there are no ignition targets. Simply put, the ignition target capsule designs which LLNL claims "ignite" in computer simulation cannot be fabricated.

A project like the NIF pushes the forefront of technology along many lines. New tehcnologies going into NIF should have been tested as thoroughly as possible prior to the construction of NIF. In Livermore's "Beamlet" laser, the prototype for the NIF, there existed the opportunity to do a full systems test of the modular NIF design concept. Unfortunately no Beamlet shot ever simultaneously tested the full set of NIF performance goals: a full energy, full pulse length shot converted to third harmonic and focused onto a target.

In sum, serious problems exist with the NIF project that merit close scrutiny -- problems well beyond the clean room issue. There is now no evidence that NIF can attain the key laser energy, power, pulse shape, shot rate, wavelength or other key design parameters, or that a capsule believed capable of ignition can be fabricated. These problems are in fact so severe that there is no technical, engineering or scientific basis for having confidence that NIF can achieve its advertised objective of fusion ignition in the laboratory. Nor is there any confidence at this time that NIF can serve as a facility where useful experiments in the region of temperature, pressure and energy density characteristic of nuclear explosions can be performed. The Task Force should use the full breadth of their mandate to comprehensively assess the NIF project. It is obvious that two weeks is insufficient time to produce a report that adequately addresses the issues noted above.

Sincerely,

/s/	/s/
Thomas B. Cochran	Matthew McKinzie
Director, Nuclear Program	Senior Scientist
/s/	/s/
David Adelman	Christopher Paine
Project Attorney	Senior Research Associate

LETTERHEAD:

UNIVERSITY OF CALIFORNIA, BERKELEY
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November 16, 1999

Betsy Mullins
Executive Director
Secretary of Energy Advisory Board
AB-1, US Department of Energy
1000 Independence Avenue, SW, Washington, D.C. 20585

Dear Ms. Mullins,

Please include the attached comments in the written record for the SEAB NIF Task Force.

Yours sincerely,

/s/

Per F. Peterosn
Professor of Nuclear Engineering
Chair of Energy and Resources

Page 2

Dear Members of the SEAB NIF Task Force:

First please accept my apologies for not personally presenting these comments, as I had to leave the meeting in the early afternoon to return to U.C. Berkeley. I am Per Peterson, a Professor of Nuclear Engineering at UC Berkeley, and Chair of the Energy and Resources graduate group. My comments relate to the coupling between NIF and graduate education at the major research universities.

Perhaps the most important goal of the current Stockpile Stewardship program is the recruitment of outstanding young scientists and engineers who will maintain, in the long term, the scientific expertise required for national security. These are the people, who thirty years from now, will sit around tables much as you are today finding solutions to problems of major national importance. Our future will rest on their shoulders.

Our Nuclear Engineering department is relatively small. Over the last three years, our three brightest domestic PhD recipients have gone to work at the laboratories, two to Livermore and one to Los Alamos. These three young researchers each have outstanding ability, and I am extraordinarily pleased that they decided to take their careers to the laboratories, rather than accept the more financially lucrative opportunities that weere available to them in industry. Put bluntly, they came to the labs for the opportunity to work on the grand challenge of inertial fusion.

NIF plays a central role in the recruitment and training of new scientists and engineers for the labs. From this perspective, by far the most important goal for NIF is ignition. Ignition is the grand challenge, the primary vision, that attracts students. My request to the Task Force is to communicate the key importance of the ignition goal. Here there are two primary issues. The first is to support the efforts to achieve symmetric light in NIF at the earliest date possible, because symmetric light allows earlier exploration of capsule symmetry issues. The second is to emphasize the importance of keeping sufficient total laser energy to provide a substantial marign for ignition.

It is difficult to overemphasize the importance of your task to recommend the optimal path to bring NIF on line successfully. Please accept my best wishes for success in your upcoming work.

With best regards,
Per F. Peterson
Professor of Nuclear Engineering
Chair of Energy and Resources

LETTERHEAD:

CHARLES WILLIAM MEIER 6597 Lansing Court
Pleasanton, CA 94566
Phone/Fax 925-846-1810
November 17, 1999

Ms. Betsy Mullins, Executive Director
Secretary of Energy Advisory Board, AB-1
U.S. Department of Energy
1000 Independence Ave.
Washington, DC 20585

Attn: Dr. John P. McTague, Chairman, SEAB National Ignition Facility Task Force

Dear Dr. McTague:

I am writing this letter because, after two days of public hearings on the National Ignition Facility, I have serious concerns about its future. You are quoted in the press as having said, "At some point along the way, we are going to have to get some sharper information." While I am a strong supporter of NIF, I also believe that sharper information is needed in order for your committee to "assess the risks of successfully completing the NIF Project" as requested by Secretary Richardson. To that end, I am providing you with some observations I have regarding the NIF presentations that hopefully will assist your committee.

A quick summary of my background is appropriate. I worked as an engineer at LLNL for 36 years, retiring in 1996. Specifically, I worked in the Laser Program as the program manager for budgets and facilities during the Argus, Shiva, and some of the Nova years under Dr. John Emmett. Outside the Laboratory, I was national chairman for the Conventional Facilities Subcommittee for the poposed and now built 6 GEV National Synchrotron Light Source. My career has been in project management and cost estimating and I am very familiar the difficulties of rendering an estimate for a big science project.

Based on my experience and the presentations, these are my comments:

1. The presentations provided an overview of the NIF, but did not address in any detail the information required by your committee's charter "to review, as a minimum: (1) the engineering viability of the proposed assembly and activation method; (2) the assembly and installation cleanliness protocols; (3) the management structure; and (4) the adequacy of the cost estimating methodology." While the problems of cleanliness were discussed, only broad brush

solutions were presented. Conspicuous by their absence were cost estimates and any presentations on cost estimate methodologies. Presumably, those have been or will be provided to your committee and will ultimately be available to the public as part of the committee report.

2. The Laboratory has stated that most (all?) of the projected overrun is related to cleanliness in the assembly and installation of the laser system. However, it does not appear from the presentations that the energy density of the beam or the glass damage thresholds are more severe than was faced on Nova and Beamlet. The fact that there are many more beam lines to assemble and keep clean was known at the onset and so I am left wondering if it is accurate to characterize the projected overrun as a surprise attributable to "recent data and experience [...] that has demonstrated that the assembly and installation of the laser system must be done in a cleaner and more rigorous and detailed manner than had been originally planned," the additional cost of which is now estimated to be more than the entire project contingency. I believe the Laboratory has said this added cost will further exacerbated by the requirement to use outside contractors for assembly

and installation. My experience would support that contention.

3. Rather than being an unanticipated problem relating to recent data and experience, it seems more likely that it is a systemic problem originating from many elements of the project that were underestimated and an inadequate project contingency (discussed next). This is hard to confirm since no presentations were made comparing project costs to original budget estimates. I think your committee should request copies of the original project cost estimate broken down by its major components and a comparison with the current cost estimate.

4. I was struck by the fact that the project contingency was only 15%. It was stated by Ed Moses that these types of projects would more normally have a contingency of 35% to 40%. From my experience, it is normal for the DOE to want a contingency of 20% on relatively straight forward "brick and mortar" construction projects and more if the project is dominated by a large science machine such as is the case with NIF. It is even more difficult to understand why the Laboratory proposed and the DOE accepted a 15% contingency in light of the chart shown by Ed Moses entitled "The economic challenge of

NIF" which demonstrated clearly that the NIF cost was projected to be a six fold cost reduction beyond the learning curve. I would also think your committee would be interested to know where OMEGA and the French megajoule laser fit on the learning curve in terms of $/Joule.

5. If the committee has not already been provided with a copy of the original NIF contingency analysis (required by DOE), it would be useful to have one. The history of how that contingency has been spent to date can be reviewed through reports provided monthly to the DOE. Any revised project cost estimate will include a revised contingency analysis which should be probed to root out unsubstantiated optimism.

6. For reasons stated below, I believe that it is important that any new cost estimate not be driven by an overriding desire by the Laboratory or the DOE to minimize the apparent cost overrun by redcing the output parameters or by burying costs in the follow-on operating budgets. The forces at work to keep the added costs unrealistically low are powerful as there is the ever present threat that increasing the project cost by "several hundred million dollars," may mean its cancellation.

If past history is any guide, this is the single opportunity the NIF project will have to make cost and schedule changes. Several years ago, in a situation not too dissimilar from what is happening on NIF, this country went from being preeminent in the field of high energy physics to accepting a secondary role (to CERN) with the cancellation of the Superconducting Super Collider project. The SSC was underestimated at the onset and subsequent estimates continually escalated the cost until the DOE and the Congress essentially lost faith in the project management and cancelled the project. World leadership in the field of high energy lasers currently belongs to the United States because of the work at Lawrence Livermore National Laboratory, the University of Rochester, and other research facilities supported by the DOE. In appointing your committee, Secretary Richardson clearly recognized that sound management is as important as good science to the success of NIF. The good science of the laser prograqm and the NIF is self evident and impressive. Equally impressive is the well managed integration of outside contractors and suppliers. I believe that under the guidance of your committee, a revised project cost estimate can be generated that will be credible and supportable by the DOE and the Congress, thereby enabling the NIF Project to meet its scientific and national defense objectives. Thank you for taking the time to read this.

Very truly yours,

/s/

Charles W. Meier

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