Moderator: Carol Martin Watts
Nexus 2000 Round Table Discussion
Methodology in Architecture and Mathematics

Panelists:
 Rachel Fletcher,
 William D. Sapp,
 Paul Calter,
 Mark Reynolds

The Nexus 2000 round table discussion on methodology in architecture and mathematics took place on Tuesday 6 June during the course of the Nexus 2000 conference in Ferrara, Italy. Moderated by Carol Martin Watts (far left in the photo), the panelists were (from left to right) Rachel Fletcher, Paul A. Calter, William D. (Bill) Sapp and Mark Reynolds. The following is a transcript of the audio tapes made during the discussion.

Part I: How Important is Accuracy?

CAROL MARTIN WATTS: Kim asked me if I would moderate this round table, partly I think because I was one of those suggesting two years ago that we do such a thing. I just recently read what she wrote in this booklet that you have, and I'm not sure we can really quite fulfill her hopes for what might come out of it. She says about this round table that "the topic is particularly relevant to the theme of the Nexus conferences because there is no accepted standard for analysis of architecture and mathematics, a lack sorely felt when one tries to draw comparisons between two studies of the same building. It's hoped that this discussion will overcome the objections of those who see mere charlatanism in numerical manipulation in mathematical analyses of architecture, a bad reputation which is unfortunately fostered by the

unorthodox techniques used in many studies.” I am hoping that today we can start the discussion; I think to really come up with a methodology that everyone should be following is likely to be something that will take a long time to establish, if it is possible at all. One of the things I would like to do today is talk about disciplinary differences which might very well mean that it is impossible to have that kind of standard.

Before we get into the specific discussion I have just a few general introductory comments and then I’ll be asking questions of the panel and then giving you [the audience] the chance to ask them follow-up questions or to make your own comments. The majority of the papers presented at this Nexus and previous ones have concerned themselves with analyses of past works of architecture; just a few papers have presented contemporary designs or proposals for design methods using mathematics. So because of this preponderance of historical analysis, I thought that that would be our focus today. It seems to me that, before we talk about methodology, we need to talk about our research questions. What are we trying to find out? What are we asking? We may not all be asking the same questions in each study but there are some very general questions that are relevant. We are probably all concerned with what mathematics is evident in the particular work or the work of a particular architect, whether it is geometry or proportion or whatever. We have to establish if it is present, what it is, or how do we describe it. We are also concerned with how mathematical systems were used in design and construction. ‘What design methods produced the end result?’ could be a question that some people are asking. There is also the important question of why – why such mathematical systems were used; what, if anything, was their meaning or significance. So we have the what, the how and the why. Any one study might deal with perhaps one of these more than others, but they’re certainly all relevant to get a complete picture.

In terms of the general methods of research, these questions are looking at historical examples, whether it’s ancient or early twentieth century, or even more recent, typically using an after-the-fact method. We cannot conduct scientific experiments, with control groups. Except in the case of very recent works, we are not able to interview or conduct surveys of architects, builders and clients, although that may be one of the methods useful for relatively recent designs. As you go far back into time, to the Renaissance or Romans, we don’t have that as an option. Essentially what we are having to do is look at observations of physical traces: what remains and is present of the work in question; and different kinds of archival research, study of records, drawings, texts, perhaps about the particular example or perhaps more general about the culture and the architect’s work at that time.

So we have these two essential sources for figuring out after-the-fact what happened and how something came about: observation of physical traces and archival. The physical traces may be rather limited, or in ruins, or perhaps they have changed over time, and in other cases are well-preserved. We have to establish whether we are dealing with something that has been changed over time or has been restored. The condition of archival information varies greatly; in some cases there is a lot of information, in other cases it is limited, or it’s nonexistent or is very general. These are some of the variables depending on what place, what time period, what culture we are looking at. It may be the fact that we are using these after-the-fact types of analysis that we can’t really prove whether our hypotheses are true. Now, although scientific experiments might not necessarily prove anything either, the general public has the sense that experiments are science,

and science is accurate, and the methods that we are using are perhaps seen as not as scientific, but that is something we can talk about. I agree with Kim that this discussion is particularly important because there is a tendency to not take seriously geometrical and other mathematical studies, certainly within my field of architectural history, and most likely others as well. So we need to think about ways in which you can make as strong a case as possible.

For today's discussion I have decided to focus essentially on two questions that are of interest to the panel here, who were all suggested by Kim to provide a broad diverse group in terms of the disciplines they are coming from and the types of things they study. Everyone [on the panel] has an interest in measurement, so I thought we would start with that. I would also like to take advantage of the variety of disciplines to talk about disciplinary differences of approach. As I mentioned before, I'll start with a question and give everyone [on the panel] a chance to talk if they want to and then we can open it up to the rest of you for follow-up questions or your own comments or debate or argument. As moderator, I will claim the power to decide when to stop the debate on something, move on to something else, or to try to direct things back on track. I have a list of follow-up questions myself but I am hoping that I won't even get to those, that you will be coming up with the questions.

Let's begin with the importance of accuracy in dealing with measurements. This has already been broached in some earlier discussion [at this conference]. How important is it to base analysis on accurate measurements? 'How important is accuracy?' is the most general question. Paul, do you want to start, since you're probably the most appropriate to get involved here?

PAUL CALTER: Of course you know my involvement in this whole process very, very narrow. I couldn't even begin to address all the questions on your list, but maybe we can talk about accuracy. What is appropriate accuracy? I think it depends on two things: what it is you are measuring, and the purpose of your measurements. First, what it is that you're measuring. You wouldn't expect to use the same degree of precision when measuring, say, the Medici Chapel with nice, clean, stone walls as you would measuring a crumbling medieval tower or some foundations in Peru, for example. It just wouldn't be appropriate to use the same precision in both cases. In the other direction, measuring a small precise pavement like Kim does, you would think that an even greater degree of accuracy is indicated there; you don't just take a measurement once, you measure it several times to get a result, something you wouldn't consider doing in all cases. So that's part of it, what it is you are measuring, choosing a method that is appropriate. The other thing is what you plan to do with the measurements. In the case of the Laurentian Library doorway, we were primarily doing a survey that we were going to publish for the use of other scholars, so there we tried to strive for the best accuracy we could without using extraordinary measures, just simply taping and triangulation. If you were using the results of the survey for your own purposes, say proportional analysis, you might want to settle for a less degree of accuracy.

WILLIAM D. (BILL) SAPP: I would like to say that in archaeology, when we excavate sites, we are often only going to be at that site once, which means that we are going to uncover walls and map the site and the results of our excavations are going to be what other people are going

to use for analysis. And so because of that I think that it's important to be as accurate as we can be. I've seen overlays of maps done of particular sites in Peru in the early part of the twentieth century and in the middle part of the twentieth century and later done with a total station and a theodolite, and the differences are quite substantial, so that regardless of what kinds of questions that, let's say, I have as an archaeologist and I want to answer with this information, I have to realize that other people are going to have to use the information that I get for other kinds of analysis, so I think it really behooves us as archaeologists to get the most accurate kinds of measurements that we can get. Given that, there are still a lot of problems in terms of accuracy and what we define as accuracy, but I still think that taping gives us one degree of accuracy, using a theodolite gives us a much higher degree of accuracy, and if we can use better methods, then that's what we have to do, realizing that we may be the last person that is at that site. Also, archaeology is a very destructive science. When we dig something up, we may decide to destroy a wall because we have to excavate below the wall to see what kinds of prior constructions existed, so that means that no one is EVER going to get a chance to remeasure these kinds of things in the future. So I think that in that sense, while we may be dealing with things that certainly aren't as finely constructed as medieval and Renaissance buildings may be, we still really need to be as accurate as we possibly can.

RACHEL FLETCHER: And also I think at this level of taking measurements it is very useful for people coming after who are going to be using them to know what the degree of accuracy is. If you can say what that is, it's really helpful to the next generation so they can know what they're building on.

BILL SAPP: Right.

MARK REYNOLDS: I remember one of the first times I decided to measure something, I had a metal ruler that said "Accurate tolerance from 68 to 72 degrees", which meant that if it were extra warm or extra cold I'd get different readings. There is an old quotation, a carpenter's quote, that says "Measure twice, cut once". I usually do three or four to be sure. I am very interested in the way that geometry has been used in a particular piece of work to reflect perhaps the philosophy, perhaps the symbolism, even the religious beliefs of the society in which this particular piece was done as a reflection of the way people thought at that time, and I think if we go back to ancient times, geometry really was used for more sacred reasons than we think today and I think that's the result of science's refusal to look at ancient structures and some of the symbolism of the circle and the square and the triangle and what the ancients thought that those particular shapes meant and if we are able to categorize that somehow technologically and bring science back to the art of what the geometry is telling us, I think we could learn a lot about our culture, our society, our civilization from the very beginning. I'd like to trace geometry back to the beginning and I think that geometric analysis is one of the ways of doing it. I'm glad that we have people like Paul that know how to use sophisticated instruments, we have laser technology now that can lend some assistance to us. I would like to see an instrument developed that could see through sand, so that we could figure out what's hiding underneath the Sahara desert.

CAROL WATTS: So you see accurate measurement and the use of scientific technique now, sort of the most up-to-date techniques to measure, as a way of helping to convince people that there is validity to such things as geometry?

MARK REYNOLDS: Well, I think there is a problem for all of us, we talk about what happens over the centuries and how things shift and change, earthquakes and floods and so on, and so I don't know whether we are having accurate measurements or not, so that's problematic.

PAUL CALTER: I'd like to go back to the phrase that Bill used, "accurate as you can possibly be". What does that mean? Using extraordinary measures? Taking each measure three times? Using better instruments? You can always make a more accurate measurement, but is it really appropriate when you are measuring, say, crumbling walls or a foundation? Would you try to measure it to a millimeter or a tenth of a millimeter; it is possible but does it make any sense in a structure of that sort?

BILL SAPP: I see what you are saying. We're talking about taping, and we're talking about using a compass for example, to lay out the plan of a building, again referring back to these overlays of plans that I have seen done with compass and tape versus what's been done with a theodolite. The differences can be substantial, and as you said, with smaller things you might want to be more accurate, and yet, I see with larger things you might want to be more accurate. If I'm taping a temple that's a hundred meters on a side and has rooms on top I have a greater chance of being wrong if I'm using a tape and compass than if I use a theodolite. In terms of what degree do you want to be accurate, I think we're all bound by the fact that we have a certain amount of money to spend on a project...

CAROL WATTS: ...and time...

BILL SAPP: ...and time, and we have to make the evaluations of how much time and money we're going to spend on that particular aspect of our project. Given that we have those restraints, I think that one is obligated to do the best job possible. I'm back to this "best job" again, but that means using the most accurate technology within the given time and monetary constraints. Taping is great, but if I've got a crew of 15 people that are working out there and some people don't stretch the tape quite as tight and we're not using surveyor's tapes and we're not using 20-lb pulls and strings to get accurate taping, I could be meters off; if I'm using a 50- or a 100-meter cloth tape; I could be degrees off in terms of weighing on these things and there are certain people who would want to take my information and understand why a building was laid out in a certain direction and how it may compare to other buildings. So I may not really care whether the corner is 2 or 3 millimeters one way or another, but I want to know whether the wall is at 32 degrees off north or 42 degrees off north; I want to know if that wall is 108 meters long or 112 meters long.

PAUL CALTER: I hear what you're saying now. The thing that threw me was that "to be as accurate as you possibly can" implies to me that you are measuring with greater precision, say

down to millimeters, in a case where the physical structure that you are measuring isn't that precise, because if you measure at the top of a wall you get one dimension, but then a few inches down [away] you get another one. That degree of precision is not appropriate.

BILL SAPP: ...right...

PAUL CALTER: I think what you are after is a reliable set of data that is pretty close, but not highly precise.

BILL SAPP: I think that's right.

MARK REYNOLDS: I think you're missing Kim's emphasis on percent of deviation as a way of verifying just how close or far off we are and by explaining the kinds of tools we've used and giving that percent of deviation we give future scholars something to go on. We better not use this old wooden ruler because it's going to be a couple of meters off versus a theodolite with a laser attachment to it, so I think Kim's emphasis is appreciated, (although I had to call her a couple of times to understand what percentage deviation meant!), I finally do understand what it means now and it's a very, very valuable tool, and an important tool for any scholar in the future to be able know just how just how far off they are. Both of you were talking about something that percentage of deviation could help.

RACHEL FLETCHER: One of the things you were mentioning, that a wall was one thing here and another over here, especially if you are taking very accurate measures and you can't take very many points, the question is what points do you take in order to really reveal an accurate portrayal, whether it's a door or whatever. In a certain sense I like the idea of someone who is taking measurements to go about it purely objectively without anyone telling them what points to take so that there isn't that bias. On the other hand I really appreciate having a team like you and Kim working together to say "There is a particular point that I feel is going to reveal something important", and yet that carries with it a certain tendency to read something in a particular way. So I think choosing what to measure is as important as how accurate the measurements are.

MARK REYNOLDS: Kim, the points were 'verifiability' and 'repeatability'?

KIM WILLIAMS: I said scientific method requires verifiability and repeatability. A result has to be verifiable and it has repeatable, and that is what we are looking for, I think.

PAUL CALTER: I think it is important especially if you publish your results.

KIM WILLIAMS: That's true. If you measure a building, someone should be able to go back and measure the same way and find those same numbers.

CAROL WATTS: Which is why it's very important that you always include in publications or

any archives of your measurements how you did it and a description of the process.

DAVID SPEISER: May I humbly point out to our directress, that one of the preferred subjects in Nexus are the symmetries. Now whether the symmetry is hexagonal or octagonal, you can count it on your fingers, and you don't have an accuracy that is very difficult to achieve; I mean, if you can't count, you can use your fingers. Second, as I was once lucky to observe, the accuracy even then depends [on what you measure]; the accuracy you need for measuring an angle is not as great as for measuring the length, it's very different. So it depends very much on the subject about which one is talking, and of course the subject comes always up when what one is up to is verifying a theory. Then what you said is perfectly accurate. And I give as a dubious example the series of discussions that we have had at all Nexus conferences about the Golden Section, and there I was always sitting with our friend Volpi Ghirardini, who demanded an enormous exactness, because there you are in trouble, and you never know what you are talking about, if you are talking about a Fibonacci series, which is very different from the Golden Section, as far as the accuracy is concerned, so it really is a question that depends on what you are talking about.

KIM WILLIAMS: Well, in some ways. Let me make a comment, though. It is one thing to count the sides and say, "The Baptistry of Florence is an octagon", but I think the next step is "how regular an octagon is it?". It depends on what kind of a theory you are trying to prove, but actually for Brunelleschi, with the cupola of the Duomo of Florence, who had the job of building the world's largest cupola at that time and spanning that octagon, it did make a great deal of difference to him that that octagon wasn't regular, because it caused all kinds of problems. And so frankly the issue of how many sides it has versus does it have that many equal sides, I think is crucial.

JUDITH (JUDY) MORAN: I'm speaking now as a mathematician, and I know in Kim's project for this discussion she's talking about, not believability...

KIM WILLIAMS: Verifiability.

JUDY MORAN: No, the discipline itself...

PAUL CALTER: Credibility

ALL: Credibility!

JUDY MORAN: Thank you. And I really wanted to reinforce a lot of the points that Paul made because I know how some members of the mathematical community would view this, that it's not just how accurately you can take a particular measurement, it's the mathematical operations that you perform on these measurements and not understanding the kinds of precision you lose. Paul was talking about that and I thought that some contribution on that might be important because I don't know if people know a lot about that. If you're just doing

the measurement, that's one thing, but if you're ever making a claim about the proportions, you have to really know how numbers work, and really understand it in order to ever prove the Golden Section, because you can't really measure it because of course it's irrational, so there needs to be a sophistication and an acknowledgment of that I think in publications for the credibility that you're looking for, that when you start operating with numbers there are other constraints.

MARK REYNOLDS: Can I respond to that? I found after 30 years of working in geometry that a lot of times the geometry will give me the mathematics rather than the other way around. In other words, that I can make a harmonic ratio in a rectangle or a square by construction, I don't need to know any mathematics at all to be able to do it and there are sometimes there are no mathematical procedures needed in order to do a particular paving, for example. Perhaps three-dimensionally or structurally speaking you may need to know the mathematics so the thing doesn't fall down, but if you're doing a paving, a lot of times you don't need to know any mathematics whatsoever, the geometry has the math in it already.

JUDY MORAN: I think we are talking a little at cross purposes. I'm not talking about the mathematics that's required to construct the structures...

MARK REYNOLDS: Okay...

JUDY MORAN: I'm saying, some people here are looking at measurements that they're taking, that's the original question, and then talking about precision, there's the precision of the individual measurements, and I'm not talking about the architect used to construct the building, but then when you perform numerical operations on your numbers to get proportions, you need to be aware of some of the things that Paul spoke of in terms of how accurate, degrees of accuracy, decimal points. I know this sounds really boring, but the results of what you do with your numbers may not be as precise as some of the individual measurements and you need to know that and refer to it in the final publication.

RACHEL FLETCHER: I don't crunch numbers, I lay something out geometrically with a compass because I aspire to get as close as I can to the intention of the proportion, but I am also getting as close as I can to how a carpenter or a craftsperson would lay it out. I don't understand why it is always the Golden Mean that seems to require an extra perfection in laying things out, while other measurements seem not to, no one seems to care very much. But a Golden Mean isn't a Golden Mean unless it is so precise that you can't even draw it, you can't even put your pencil on the paper because the thickness of the line compromises the accuracy. You can never get as perfect a Golden Mean as can be conceived in your mind. Architecture is meant to be experienced, it is meant to be lived in, it is meant to be perceived, it has all of those experiential qualities which I think don't require the super perfection that only the mind can hold.

JUDY MORAN: That's not what I was talking about. All I was talking about, and this is a huge

issue, is the very rudimentary numerical sense that of those people who take measurements, and some people at this conference were spinning out numbers in the decimal places, and when you do that and then you take one and combine it with another one to get ratios and things like that, then you need to be aware, in terms of credibility, of how precision works under plain old arithmetic operations, that's all, so that when you talk about your results you don't claim an accuracy of proportion that is greater than you can get from the input.

PAUL CALTER: So that wouldn't apply to a purely geometrical analysis, but to a numerical analysis.

CAROL WATTS: So if you're adding up a string of numbers for example, even if each one is very accurate, the total may not be.

RACHEL FLETCHER: For example, I was interested in Mark's derivation of the equilateral triangle and the Golden Mean, because mathematically speaking you cannot reconcile two incommensurables; that is not possible, and everybody knows it. But the fact that there is such an intersection suggests a potential in the mind to bring them together. The great geometric exercise that all of us go through, that we have all been searching for, is the squaring the circle, reconcile the perimeter of a finite form with an infinite form. Now we attempt it not because we feel we can accomplish it, but because in the quest there are all kinds of values and qualities that come about through the exercise of it. That's a part of the experience. I think that's what we are looking for.

MARK REYNOLDS: I agree with you and I think that sometimes the mathematician and the artist hold hands and everything goes really well, but sometimes we part company when mathematician says, "A line has no width." Well, an artist is going to say, "I'm sorry, but in my drawing if it has no width, you're not going to see my drawing." So sometimes we agree and and sometimes we don't and I think if we could come back together as artists and mathematicians together, that would really help to solve this issue that has been brought up.

PAUL CALTER: I think we are getting far afield here. All Judy is saying is that if you do use numbers, measured quantities, and carry them through a computation as some of us do, you should know how the accuracies or inaccuracies propagate through the computation and treat the numbers properly.

JUDY MORAN: That's all!

CAROL WATTS: Let me say something as moderator. I think this is a good example of the differences between the disciplines, even in terms of communicating, right? A mathematician, an artist, an architect, an archaeologist think in very different ways, communicate in very different ways, and that's what's good about a conference like this is that we are coming together, but it can be easy to have misunderstandings.

PAUL CALTER: There's a difference between a numerical approach and a geometrical approach...

CAROL WATTS: or a visual approach...

MARK REYNOLDS: Can't those numbers change, though, over time? I mean, we've all seen like something shrinks over years, or there's an earthquake and it bends. How do we know that the numbers themselves are telling us the truth?

RACHEL FLETCHER: Well, that's the question that I have with buildings. I mean, we're all talking about taking simple, accurate measurements of buildings which have settled over time. Are they closer to what was intended than the original working drawing? I mean, what kind of tolerance do you have in the case of settling?

PAUL CALTER: I think we're not really taking super-accurate measurements to begin with. We're using very basic surveying techniques, taping, usually just once, without repeating the taping; we're not making corrections for temperature or sag or for pull, just doing the measurements...

RACHEL FLETCHER:... the best you can do...

PAUL CALTER: ...the best you can do, and I think in most cases it's more than enough, because of the things you've said, because of irregularities in the buildings, and of alterations that may have occurred, because of earthquakes and floods and bombings. I think taping is fast and simple, it's not an extraordinary means, and it gives you accuracy that's fine for most cases.

MARK REYNOLDS: Do you think that most mathematicians feel the way you do?

PAUL CALTER: I think they do, sure, sure.

CAROL WATTS: I think Leonard had a comment earlier.

LEONARD K. EATON: Yes, I'd like to see a little more effort at thinking back to the design tools that were used by the people laying out architectural objects. Now, I am not a historian of technology, but I will bet that Michelangelo did not have a theodolite when he laid out your doorway. I visualize the old boy as having something like a yardstick and maybe a compass and perhaps a triangle, and those instruments survived until well into the nineteenth century. So I just would like to see, when this whole issue of measurement comes up, a little more emphasis on what the architect at a given time had to do design and layout with.

PAUL CALTER: I think you're interested in what kinds of precision, what kinds of tolerance were acceptable during the periods...

LEONARD EATON: Sure...

PAUL CALTER: and I think that's important..

CAROL WATTS: And that's the kind of information that architectural historians can find in some cases. There may be correspondence, there may be instruments that have survived

PAUL CALTER: But when we go now to measure an existing building that may have been put up with crude tools, I don't think you are suggesting that we should use similarly crude tools to measure what's there now.

LEONARD EATON: No, but I am talking about Wright's windows tomorrow and I had a substantial difference with a scholar at Wisconsin who came up with some results for his measurements of a window that I think were a great deal finer than any that were available with the instruments that would have been used in Wright's office in 1904.

PAUL CALTER: Hmm-mm. I think he's padding the data.

LEONARD EATON: No, I don't want anybody to go back to using the tools of 1600 or 1700 or 1800, but I want us to think back a little as to what was available when things were laid out, designed and set up for us to measure centuries later.

MARK REYNOLDS: What a wonderful thing it would be for us to find Michelangelo's set squares. You know we could get up to the door and could just actually take his tools and use them to see how they work in that doorway and forget all the modern stuff that exists.

KIM WILLIAMS: I think I could use Michelangelo's tools and I still wouldn't come up with what Michelangelo did.

CAROL WATTS: Because he didn't build it himself, right?

PAUL CALTER: The problem is that the superintendent of these places won't let you do that; they won't let you go up the walls and measures with tapes or anything, or go anywhere near these things, so you need an indirect method like a theodolite or a transit just because you can't get permission to go and measure directly.

LEONARD EATON: That's one reason I stick to windows.

Part II: Do the disciplines agree on the nature of mathematics?

GUILLERMO LEÓN DE LA BARRA ALVAREZ: I have a more elementary doubt. I for my English, but I hoped (I think maybe I am wrong) in this "Round table: Methodology for mathematical analysis in architecture" to discuss a methodology that can be used in

architecture. There are two kinds of general models: qualitative models and quantitative models. I won't change the focus of the discussion, but at this moment I suppose we are discussing the quantitative model. I know that all these precisions are based in Euclidean geometry, considering proportion, curves, the Golden Section, etc. But that is one step of the analysis, or one way to look at the architectural model, I suppose (I am not an architect). But there is another kind of possible step to take in mathematics, a qualitative step, that using topological and dynamical structures, and it could be another way to begin to study the architectural models. Dynamical and topological structures are more complex, considering not only metric relations and proportions. If you consider, for instance, a model of a Raphael painting, Notre Dame cathedral, Strasbourg Cathedral, etc., and you take up the model, a static model, and consider a set of points, lines and graph then you can compare them. But this is one level of comparison. Maybe they look different in that level, but as you are studying a second level, what then? Adding a dynamical or topological structure, maybe it could happen that we have less or more models. You might end up considering that the model corresponding to Notre Dame Cathedral as the same type of a Raphael painting. But then it could be possible and convenient to consider this another point of view to study an architectural model, not only from the point of view of a static model, but also a more dynamical and topological one. On the other hand, I think that it is really important to look at the past, but also to project the future, and now we have the technology, the computer, it is easier to put a dynamic in any structure and follows its space-time development. At the same time by considering an appropriate mathematical model, you can discover that, for example, 300 lines or points and several curves, can be reduced to a few classes of objects, and it is easier to study 6 or 7 objects than 300. I think that a quantitative method, using essentially Euclidean geometry and trigonometry, is a good way to study and compare architectural structures and artistic creations. And you don't need to use high level mathematics (homotopy theory, algebraic geometry, etc.) to be rigorous. But now, I suppose, a possible next step for a methodology for mathematical analysis in architecture could be to consider more dynamical and topological models. I suppose I changed the focus a little, but I wish and need to know more about this.

CAROL WATTS: Does anyone want to respond to that? I'm not sure I followed all of what you were saying, but I think you were certainly making the point that there is a variety of types of analysis, that measurement, which was our focus here to start with, is perhaps not relevant to all types of analysis.

KIM WILLIAMS: I think it comes also to the question of what your goals are. I think in this case what your goals are very directly connected to what kind of analysis you choose.

RACHEL FLETCHER: I want to comment on that. I've moved on from my research on Palladio and am now working on some of the architecture of Thomas Jefferson. We know a lot about Thomas Jefferson, but we don't know about his work in geometry. He doesn't provide any geometric analyses of his drawings; he doesn't provide us with that information. So I am doing what to many people would be a very speculative kind of inquiry, analyzing the

drawings that he himself studied. He worked with the Leoni edition of Palladio's drawings of the Pantheon, and I thought if I studied those geometrically, and looked at the proportions came out of them, even though the measures of the buildings are totally different, would there be the same proportional techniques as in the Rotunda? And I am finding a lot of similarities. So what you are saying about trying to distill from a multiple of things is happening. To me that is a worthy pursuit, but there is no proof, you know, because it's very speculative, and yet it has been very rewarding. And I think that all of us who are in this area of inquiry, I mean, it's all speculation. I mean, we're trying as twentieth, twenty-first century people who were raised to see the world in a particular way, to see the world in another way. And all we can do is try to see, I mean, we all have to understand that we are exploring on faith, but if we don't explore those possibilities then we will only stay where we are now. We have to understand that they are only possibilities, but we have to give room to explore them.

KIM WILLIAMS: I think that though that we can explore a building and learn a great many lessons without having to put words into the mouths of the architects. Personally I've been criticized a lot for speculating, and I think the way around that is, I mean, there are certainly characteristics of the building that are objectively there, and even if you can't enter into the architect and you may not know if he meant to, but they are still there, and at that point we are very free I think to abstract those and make them known.

BILL SAPP: I think that for people dealing with historic architecture, you've got other lines of evidence that you are able to follow so that, as was brought up the other day, you could deal with the theological concepts of the time and try to understand architecture or the measurements you've taken or the perspective or whatever; Dr. Speiser was talking about relative to the religious concepts we can follow as well. I think the big danger as you point out is confusing our analysis with the intent of the architect, the intent of the builder, and that's a particular danger for archaeologists or people dealing with prehistoric societies where we don't have that sort of information available to us, so that we have to be very explicit about what our analysis includes, why we are doing it and how we are going to interpret it and present that interpretation. And to realize that it's our interpretation and that the context is our western mentality. I don't want to be too postmodernist about it, but there are certainly culture contexts that govern the kind of interpretations that we have that may have nothing to do with what the architect did.

CAROL WATTS: I wanted to ask another, related question. We talked about accuracy of measurement. What about, getting away a bit from the measurement, what about consistency of the use of a particular mathematical system? Let's say we found the Golden Section, or *ad quadratum*, or whatever.

RACHEL FLETCHER: Really important. When somebody shows me that there is an absolutely precise, spot on Golden Mean Rectangle on the facade of a building, I do not care, because it's just a ratio, just the difference between one side and another. That has nothing to do with the real value of proportion, which is the relationships between those differences. If that

Golden Mean rectangle then divides and subdivides and subdivides again, continuing to highlight the important parts of the building, so that there is a logic behind the use of it, that carries through from the general to the specific, then I think that there is justification, even if that analysis is 2-3% off. I'd rather see that kind of approximation if it's been carried through so that you can almost hear it as a musical composition, then I think it's interesting.

MARK REYNOLDS: I confirm that from an artist's point of view, and I always wondered why the half-diagonal of a square, when you use the half-diagonal of a square it always connects you to your umbilical chord where you were connected to your mother. It's like, "How come it works like that?" Why is that? I just thought I'd say that. When you get hungry, that's the very first place that you recognize the Golden Section area of your body, "Oh yeah, my Golden Section!"

CAROL WATTS: Any other comments on that?

DAVID SPEISER: I would like to make a discussion a little concrete, that is, I give a concrete task to the people in this case who are up to measuring Michelangelo.

PAUL CALTER: We're on the spot!

DAVID SPEISER: Which they do in wonderful way, and precisely in the Sagrestia Nuova, where they are in fact working. You all know that the four famous figures placed around the space sit on these perfectly curved sarcophagi, and incidentally, these are the same curves which you see in Raphael's *Sposalizio*, but inverted. So, what are they? First of all, I would like to point out that you can measure them as exactly as you wish, you can of course measure the height and put it into a table; I doubt that this brings you closer to the solution. In fact, a very precise and accurate photograph informs you, brings you as much and more information as a table of numbers. So it's not the numbers. Now, what can the answer possibly be? The answer will in any case be a kind of theory. And I have to verify that theory. Which is not what a mathematician usually does; a mathematician can classify the curves. I will just need the proportion, which you can very easily falsify...

PAUL CALTER: I'd be happy to...

DAVID SPEISER: ...which would make Sir [Karl] Popper extremely happy, who said, "So it's a theory, then it can be falsified." And I think my proposal would be the following, though I'm sure you'll have a better one, and the mathematicians would have another one, I think Michelangelo and Raphael were thinking of steel blades, which they curved this way and were inspired by the natural tensions and forces which are in these steel blades. Now you can make this experiment. Then you can see does it comes close in any way to what Raphael had painted in the *Sposalizio* or what Michelangelo had put in his sculpture, and then it is up to you to say this is as close or as far from the truth. Of course, you'll have to change the different steel bands...

CAROL WATTS: So you can actually do some scientific experiments.

PAUL CALTER: This is quite do-able by the methods we use with the theodolite, measuring points along the arc and then using curve-fitting techniques you could decide what kind of a curve it is, and then you could do the same thing with a steel blade and compare the two and see how they compare. They won't of course compare exactly, but you could decide if it is close enough to verify this hypothesis or not. And if you'd be willing to write a small grant, we'll be happy to go and do this.

CAROL WATTS: While we are waiting for the tapes to be working again, what I'd like to do is ask if there are other ideas to share about how do you get started? How do you know what to investigate?

KATHLEEN (KATHY) REYNOLDS: Carol, I think this is the creative part of the scientific method, where you are researching, proving a thesis, recording, analyzing on one topic, and during that process you will bump into something that you may save as an idea; in the back of your mind you are saying, "When I finish this, I would like to look at this." It will give you the stimulus, your success in one area will stimulate you to then investigate another area. I've seen this in Mark's projects, where he'll say, "Well, this is another thing I want to look at one day". I think that's a creative aspect of being scientific, doing a lot of research also.

CAROL WATTS: One thing leads to another.

MARK REYNOLDS: There's an aesthetic, a desire to want to know how something is structured, its beauty and so on. When you begin to realize that you can find so much geometry in nature, and when you go back as far as you can to the caves and you see stick figures whose legs are triangular shaped and you see branches of trees that remind you of things geometric, I think you are just naturally inclined to want to know something about geometry because it's what builds what our world is, partly at least. And I think all of us go to those things that attract us of their beauty, or because are amazed or stunned by them; we're dumbfounded by how could somebody even do that.

KATHY REYNOLDS: Rachel, did your study of Palladio grow out of something else?

RACHEL FLETCHER: Yes, that was an unusual one...

KATHY REYNOLDS: But that was my thought when you you said that you were doing Jefferson.

RACHEL FLETCHER: Yes, I deliberately moved on to Jefferson after Palladio, because for me it's been kind of a journey around the world trying to come home. I started with ancient Greek and Roman theatres, then gradually moved on to Palladio. Now I see that all this time I've been trying to get home, and right now, it's Jefferson. But as I say I think probably the most important thing I ever learned from my geometry teachers was from Lucie Lamy, the

stepdaughter of Schwaller de Lubicz. I was very lucky to be invited to prepare some of her drawings when, in her later years, her eyesight began to fail. I don't have a sophisticated background in geometry at all, and at first she was kind of stunned that I didn't have the mathematical training. But she went away, and then she came back and she said, "Oh, no that's the best because you don't have to unlearn everything, you can start from scratch." And through that process the most important thing that I learned was not to impose what I wanted things to be, just to listen, to realize that whoever I am brings to the work certain limitations, and that the best I can do is get out of the way and let the work speak to me. And I try as hard as I can to do that, so I try not to say, "Gee, I have a theory to prove; I'm going to stick it on here." I rather try to meet the project at least on neutral terms.

MARK REYNOLDS: You know, I wonder. When I taught elementary school student teaching back in my old college days in 1880, I wondered why kindergarteners and first through third grade, when you would give them tempera paint and an 18 x 24 sheet of paper, why they would always use the circle, square and triangle to make everything. It was their family, it was their brothers and sisters, it was their neighborhood, it was their mother's car, it was just everything in the world. I wondered from the beginning, you know, we don't talk about the collective unconscious, but where did this geometry come from anyway? I mean, we didn't invent this geometry; this geometry was here before all of us were. Before any human being came to earth in any way, shape or form, geometry existed. So was geometry there at the very, very beginning of the Big Bang (if you believe in the Big Bang)? Was it responsible for the Big Bang? Was it the result of the Big Bang? Was it there before the Big Bang? Or, if it happened in between the Big Bang and the present time, who or what invented geometry? Or, does geometry have its own living consciousness throughout the universe? I don't know the answer to it.

CAROL WATTS: When I published my article in *Scientific American* on the Roman houses at Ostia, it received a very wide interdisciplinary audience because of the publication. I received a number of letters, including several from neurosurgeons and scientists studying brain structure who were fascinated by it and saw a relationship to their work of the structure of the brain. They were from Eastern Europe and the Soviet Union and places like this, from all over the world I was getting some of these letters. I didn't understand the details of what they were trying to tell me but it clearly resonated as geometry (and this was fairly simple, the Sacred Cut), that geometry was somehow innate in the structure of the brain.

MARK REYNOLDS: Did you see the January issue [of *Scientific American* magazine]? The human skin is covered with small equilateral triangles that conduct electricity. Well, they did a study and said that our skin is very similar to the way Buckminster Fuller did his work. I don't know if that's true or not, I'm just telling you that that's what was reported in the *Scientific American*, for whatever it's worth. We may even have equilateral triangles all over our bodies and not know it!

RACHEL FLETCHER: I have to disagree. I do think that there is probably a relationship between geometry and the structure of our brains as we understand the structure of our

brains. I'm on the side of thinking that mathematics is probably a human construct, but that doesn't make it any less of a miracle. The wonder of geometry is not how it was created, but the magnificence of the complexity and the richness of it.

PAUL CALTER: Can Judy get a word in? We have a real mathematician here...

JUDY MORAN: Because all of our talk has only of course been about one geometry. And when you were talking, you were just talking about Kant, right? and Kant's theory of knowledge.

MARK REYNOLDS: Exactly.

JUDY MORAN: My field is actually hyperbolic geometry, partly. So here is Kant who believes that the brain is hard-wired to perceive Euclidean geometry and that that's what we have to have, and then the nineteenth century comes along and we discover that we can have any geometry we want. And so we can have curvy triangles, we can have hyperbolic geometry, we can have all kinds of non-Euclidean geometry, which is in fact the basis of relativity theory. So we can pick and choose our geometries, I think.

MARK REYNOLDS: What's that that Descartes was taking a nap one afternoon and he was looking at the ceiling and he said, "Gee if there was a fly in each of the four corners and each one of them saw each other out of their right eye, and started to walk towards one another, what would the resulting pattern be?" So did that come from the construct of the brain, or was that just something creative that he came up with? There's no answer I guess to that, but...

KIM WILLIAMS: I want to say something about this as an architect and not as a mathematician. I think it's possible for us to have whatever geometry we want, but I think, as an architect and maybe a person just walking on the earth, we want it to be Euclidean geometry, and we don't want our builders to know that parallel lines ever meet. In a very practical sense, I think our first experience of the world is as Euclidean geometry, and that is, we are vertical beings on a horizontal surface. I think we need horizontal surfaces in order to move because we could have hyperbolic floors with hyperbolic tilings that would be really beautiful, but we'd trip a lot.

MARK REYNOLDS: Escher, when he did his circle limit series, was using that type of geometry.

JUDY MORAN: Oh, absolutely...

MARK REYNOLDS: All of the points were outside the circle but when you look at the pieces they are geometric as can be. So maybe the architect could use some Escher.

STEPHEN R. (STEVE) WASSELL: I just want to say one thing, that mathematics is discovered, not invented.

DAVID SPEISER: Say it again?

STEVE WASSELL: Mathematics is discovered, not invented.

DAVID SPEISER: No, it's both actually.

JUDY MORAN: Mathematicians don't agree on that. That's a big debate in the math community.

KIM WILLIAMS: Who said that's not true?

JOSÉ FRANCISCO RODRIGUES: I said that mathematics is a human creation. It's not that something that exists independent of man. Of course, when man created mathematics, he creates because he lives in this world and because he wants to master the world he lives in. So I do not think that geometry has anything to do with something outside us. Of course...

MARK REYNOLDS: You are saying mathematics and Steve is saying geometry...

STEVE WASSELL: No, geometry is math.....

JOSÉ FRANCISCO RODRIGUES: Well, what is geometry? Geometry is what? A chapter of mathematics? What is the difference? Geometry is a small subset of all mathematics.

MARK REYNOLDS: Because I can make a circle and not know anything about math. I wouldn't have to know π to make a circle, I could just do it.

RACHEL FLETCHER: You should read the *Meno* dialogue.

JOSÉ FRANCISCO RODRIGUES: But are we sure you are making a circle? You are making a physical circle, but when you think about a circle as a mathematical object, that is a different thing; that is a human creation. When you make a circle...

MARK REYNOLDS: But, see, I'm in trouble because I separate geometry from mathematics, so I'm already in trouble; I separate the two.

JOSÉ FRANCISCO RODRIGUES: Why? What is the difference? Why do you separate them?

MARK REYNOLDS: I'm not really sure...

JOSÉ FRANCISCO RODRIGUES: Is geometry so important for you, and mathematics of so little importance?

MARK REYNOLDS: No, no, it's not that at all, it's just that it is easier, I suppose. The number and the math are present in the geometry. You can find a lot of mathematical formulae by doing analyses of the geometry that is already there. I mean, the spheres in the universe have

been there...

JOSÉ FRANCISCO RODRIGUES: They are not spheres...

MARK REYNOLDS: ...well, whatever you want to call a star...

KIM WILLIAMS: But a planet is really not a sphere...

MARK REYNOLDS: Okay, whatever you want to call a planet...

KIM WILLIAMS: But it's not a matter of what you call it...

GUILLERMO LEON DE LA BARRA ALVAREZ: Maybe most of you have reason, and that is a great problem, when two people have reason, they can't reach a point, because they are talking from a topological point of view. What you see is not a sphere; it could be a cube, you don't know that, because it is transformed, this sphere, but this is the oldest discussion and it is not finished here...

JOSÉ FRANCISCO RODRIGUES: ...no...

GUILLERMO LEON DE LA BARRA ALVAREZ: ...because one is the abstract object and the concrete object, you know? Mathematics, somebody said, is a language, and others said it is created, and another said it is discovered. But mathematics is more than all that, because it is the same as architecture. Architecture, I suppose, I have talked with some close friends who are architects, and they told me that architecture is art, technology, philosophy, sociology; it is everything. So it is multifaceted. To study architecture you must merge, in a mathematic way, in every dimension of the space, so it is very difficult, and I agree with you, that when you look at something, you look at the sky and you look at the star, you find all the polygons, all the structure of the Euclidean geometry, of the spheric geometry, hyperbolic geometry; you find everything. But let me retroscind, in mathematics you have an object, when you study homotopy, you can find something that is called the generator, and it is a mathematical object, and it is very real. It is so real that you can use your cellular phone to make a call, so it couldn't be more real than that. But you don't see that inside your telephone there is a chip, and a circuit, and the circuit is a piece of wire, but why can you take a piece of wire and use it to make a call? Because the engineer or two engineers have adapted that wire, have changed its position and put in this pole and this other pole in such a way that you can talk. And this is the difference...

Part III: How do we differ in our approaches to the whole relationships of mathematics and architecture based on our disciplines?

CAROL WATTS: Let me, at this point, ask a general question, which is what I think we are getting at here: How do we differ in our approaches to the whole relationship of mathematics and architecture based on our disciplines? You know, we've already talked a bit about just how

our bias of our own culture obviously has an impact on what we're looking for, how we see, what kind of methodologies we use, but also it's clear that the more we discuss, the more even definitions of terms, such as "is geometry a subset of mathematics?" or "what is geometry?" or "what is mathematics?"; we could debate these endlessly. But maybe it would be useful to give a sense of some of the basic differences between our disciplines in terms of how we approach similar kinds of analyses, because it seems to me that that's something that can stand in the way of communication; not that there's one approach that's right, but that there are clearly values to differing sorts of people from different backgrounds asking similar questions or different questions about the same thing. But we need to be able to communicate with each other as best as possible and that's where there could be a possible danger.

JUDY MORAN: And we need to be able to build on what others are doing...

CAROL WATTS: Right, that's true too, we need to be able to understand that no one discipline can necessarily study a particular question completely, just because of inherent biases. Now, interdisciplinary teams, a mathematician and an architect together, can perhaps overcome some of that. Maybe that's one of the things that can come out of Nexus, is we know people who have similar interest but perhaps different backgrounds that might be able to do some joint work in the future. So I guess there are a couple of questions here. One is "How do you see your discipline as different from the other disciplines?". The other would be, "Do you think there are ways in which you could take advantage of approaches that other disciplines have to work in a more collaborative fashion?"

BILL SAPP: I think that, getting back to one of the things that you said earlier, from my perspective [as an archaeologist], I'm searching for order in patterns, and whether mathematics was discovered or invented or whatever doesn't really matter, that's the language that I need to use in order to describe things. It doesn't matter where it comes from, that's sort of the common basis that we all have that we can communicate with. In dealing with non-Western cultures, and from what I've heard over the past two days, I think part of discovering order and patterns, and one of the difficult parts, is separating universals from cultural constructs. What things are universal?; what occurs in Italian Renaissance architecture that occurs in Pre-Columbian architecture or Mayan architecture or Mesopotamian architecture; what are those particular things that had to do with their own belief system or ideology or cosmology or their own view of the universe. That to me is the most difficult part. I think collaboratively that, at least from my perspective, I know very little about mathematical analysis. I know when I see something that there are patterns, but how to pull out of those patterns real mathematical meaning so that I can now communicate those patterns to somebody else is something that I can't do without the help of other disciplines. And I would think and hope that others might feel the same way.

KIM WILLIAMS: Does anybody want to go to Peru?

ALL: Yes!

MARK REYNOLDS: I mentioned earlier about squaring the circle, and it could be seen also as the Yin Yang, from the great goddess Yin Yang who divided the universe into male and female. There is a positive and negative charge to almost everything in this universe and without those two different opposites, you and I wouldn't be here today. And for me, when I see a six-pointed star, or I see the Yin Yang symbol, or I see an attempt at squaring the circle, it makes me feel that working with geometry is almost a responsibility that I have to myself, to see just how much geometry exists. And it's extraordinary how much geometry exists. I approach my geometry from that point of view, the unity-duality principle. And I do admit to looking at the symbolism and looking at the religion and looking at the philosophy and looking at those touchy-feeling things that some mathematicians would yell at me about, but I do anyway. I feel at this stage of the game that the geometry works with me more than the other way around. The more I work with geometry, the easier it gets for me to just start drawing and just let geometry pieces come out of my hands, so that's why I do it.

PAUL CALTER: Well, as you know, I'm part of a team. Maybe I'm Yin and Kim's Yang, and Susi [Knight] is the unifying principle. I think that's a very good working model, with each bringing their own insights and expertise to a fairly complicated problem and working with their own strengths. And my role is very limited, obtaining accurate dimensions that Kim can then use to make drawings and look for relationships.

KIM WILLIAMS: When I'm not giving conferences...

PAUL CALTER: When you're not giving conferences.

RACHEL FLETCHER: It's not how I work with others; I guess it's more how I work with myself. It's a combination of work and play. I try to be as rigorous and discerning as I possibly can, and at the same time to allow room to be imaginative and playful so that maybe something that might never have been thought can come into play. I try very hard to balance rigor and imagination and try to conserve both.

CAROL MARTIN WATTS: Do we have any related comments from the audience? I think we'll be finishing up shortly, so some last words.

JUDY MORAN: About what Bill had said. Many mathematicians would define mathematics as a search for pattern.

PAUL CALTER: Yes, yes.

JUDY MORAN: So, there's not an unbreachable gulf, okay?

CAROL MARTIN WATTS: So perhaps there are more similarities in our disciplinary approaches than we are aware of, maybe the language we use or the preconceptions we have of what other disciplines are like may be getting in the way of the commonalities.

PAUL CALTER: This is a good point to get in a plug for Nexus. That's why conferences of this sort are so important for bringing together people from different backgrounds.

MARK REYNOLDS: I think your point about patterns is well taken. It's one of the few things that we find all over the world from the earliest of time. The human brain itself is a pattern. And from that point forward, we are all looking for patterns that exist. I totally agree with you.

CAROL MARTIN WATTS: Okay, your last words, David.

DAVID SPEISER: As the moderator said, the last word. Now, when I think over these things, I like to think of concrete examples. Now, if we think of the architects here, we must of course think of the very greatest of them, of which, in this country, there has always been a great lot. Now what do we admire in them? We admire of course their craft, we admire their views, but most of all I think, and for me that would be the last word, we admire in them their creative imagination. Now, what how does mathematics come in? If you would ask me "what is mathematics?", the old, of course, the elementary rules and the Pythagorean theorem etc.. But really, why does it come in and can claim to have contact with the arts, which are creative and imaginative. Mathematics, ultimately, I would say, its greatness and significance is that it is imagination made methodical and systematic. That's what mathematics is, and this is why the two must come together, and why we are grateful about the Nexus. Of course, the word imagination is easily said, but a great imagination, a creative one, is very rare. But, the products, in this country, can be admired of all the corners of all the streets.

PAUL ROSIN: I want to say one word since I didn't get around to saying anything before when you were talking about verification of the data, but in many scientific disciplines what's also very important is verification of the solution you are proposing. So we have for instance that a lot of the questions start off with asking, we have several possible models. We have Dr. Speiser suggest that maybe we could have a model for that certain curve as a certain tension in some steel and maybe we could have some other models. Well then what you have to do is verify which of these models fits best and maybe that's the stage in which a mathematical statistician comes in. But I don't think in any of the talks we've heard in the last couple of days we've heard very much verification of the solutions suggested. If we have a number of 1.6 that appears, is that the Golden Ratio, or is it $1-2/3$, or neither? I think we need to have some more rigorous analysis of that.

STEVE WASSELL: Like Judy, I was glad to hear Bill say that he is very interested in finding order in pattern. I agree that that's what mathematics is, on some level at least, and I agree with David that mathematics is also a very creative process. I also think though that we are a very selected group here, and I think that the people in this room really probably do have a lot more similarities than differences. But we have to realize that, if you want to say, the mainstream architects and mainstream mathematicians might not feel the same ways that we do. You have to keep in mind that we have a wider audience out there that is very scrutinizing

and we have to make sure that we present ourselves in the best way possible to that wider audience as well.

MARK REYNOLDS: Is it possible to convince them ever, do you think?

STEVE WASSELL: Well, you won't be able to convince everyone...

MARK REYNOLDS: Well, the majority...

BILL SAPP: There's certainly a great debate in anthropology about patterns and whether they should even be looked for. There are certain people, like myself, that think there are patterns of social evolution, and we're looking for those kinds of patterns. What make early empires in China similar to early Mesopotamian and Mayan and Inka empires?; what makes this cultural evolutionary process the same the world over? And there's another group of people who says, in doing so, what we do is take humanity out of the process and we make it as if the process predetermined what people do, and we dehumanize, in a sense, the cultures that we're taking a look at. And these people are saying, therefore, that you have to look at the individual and it's individual decisions that are being made that drive cultural evolution. So even within anthropology and archaeology there's a great debate whether it's worthwhile to look for patterns, let alone whether there are patterns at all. So I in particular believe there are patterns, that there are patterns in social evolution just as there are patterns in architecture, and when I was referring to the math, I felt that I was really speaking in terms of the architecture that I see in non-Western cultures, that there really are patterns. But I believe there are patterns in virtually everything because I think there is some sort of psychic unity in mankind that really says that, worldwide, people react to certain situations in certain ways because, frankly, there are a limited number of responses that are available to humans in most situations and that therefore we tend to make certain decisions worldwide, when confronted with the same sorts of problems.

CAROL WATTS: Does anyone think that this kind of round table discussion should be continued at the next Nexus, and if so, what would be a good focus? I knew that this would only be a starting point. There are way too many issues for us to cover all of them. Perhaps we could have had a more descriptive title in terms of just what was to be covered; but that was decided once we knew who the group was. So any suggestions? First of all, should we do it again?

ALL: Yes.

CAROL WATTS: Okay. And what would be suggestions for topics to focus it down a little bit so we would have a starting point for a discussion?

RACHEL FLETCHER: I love Kim's idea of taking one building and different scholars...

CAROL WATTS: ...and different approaches to the same building.

KIM WILLIAMS: That was felt by some to be too specific. People felt that if we focused on one building, it wouldn't generate enough interest. But I think we could use it maybe as a springboard...

CAROL WATTS: I would agree that as an introductory springboard ... Part of our problem is that we are talking in very general terms, and our own research is so varied in terms of the culture and what it is we are looking at, but if we could control one variable maybe we could talk more about different approaches.

RACHEL FLETCHER: We just need a moderator like Carol who can extract the principles so that it's not just about the building.

CAROL WATTS: The idea would be a beginning point for discussion, not just a series of talks on the same building.

MARK REYNOLDS: Carol, suppose we took a number of buildings, wrote them down on a sheet of paper, folded them up, put them in a bag, so that it was totally random and each one of us had to do whatever we got. I mean, that way there would be no prejudice.

KIM WILLIAMS: Yeah, but what would they have to do?

CAROL WATTS: You'd have to do the analysis.

MARK REYNOLDS: You'd go and do your analysis...

KIM WILLIAMS: ...and then ten years later...no, what you need is people who have already approached a building from some point of view.

CAROL WATTS: So we'd have to pick a building that a lot of people have analyzed.

KIM WILLIAMS: You'd have to pick something like the Pantheon that everyone is familiar with...

CAROL WATTS: ...and that a number of people have studied ...

KIM WILLIAMS: Like Rachel said, you'd have to have someone who was able to extract from individual comments the thematic that would structure the discussion.

PAUL CALTER: You said you were going to have a 'call for papers' for the next conference. Maybe you could see what comes in and find some that group around some theme that could be the subject of a round table discussion.

KIM WILLIAMS: You could maybe do it around a period, like the Renaissance, and have people who have looked at different buildings but they're still looking within the same social context.

CAROL WATTS: I think the suggestion of if you had papers with some similar themes, maybe there would be several on the same building, or by the same architect.

PAUL CALTER: It may just happen that a logical grouping would appear in the papers that were presented.

CAROL WATTS: And then that could be the basis for a discussion that would be specifically comparing the methods used by those people.

PAUL CALTER: And you'd be working with what you had already had at hand, rather than making something up.

RACHEL FLETCHER: I have just one comment. You were saying something about picking just the best papers for the next conference. I would rather see papers that have a relationship to one another.

KIM WILLIAMS: Well, I agree with you; that's what I've always done. But if you issued a call for papers, and you mentioned specific topics, you be likely to get more than one paper about a certain subject and then you could pick the strongest. In every conference there are always a couple of weak papers also, so hopefully what you'd be doing with a 'call for papers' is generally raising the level.

KATHY REYNOLDS: And was your focus going to be on Asia?

KIM WILLIAMS: No, I mentioned that strictly as one of the areas that hasn't been gone into yet that I think needs to be. I don't want Nexus to be a European, Renaissance, or 15th century conference, I really don't want that to happen. The other thing that has been suggested for Nexus, is that every conference have a theme, so we should have a conference just on Leon Battista Alberti, then we should have a conference just on Roman architecture, which is kind of interesting but exclusive, and we don't want to be exclusive; we want to be inclusive, at this point. When we reach the point where we've had 10 Nexus conferences and we've had a wide range of material, then at that point it might be time to focus, because we are focusing from many different view points, but not yet.

MARK REYNOLDS: So we just don't have anything from the Far East; we have the Middle East, and we have Europe...

KIM WILLIAMS: Well, we just barely have the Middle East. We don't have Russia, we don't have the Far East at all. Your contribution on Egypt in the *Nexus Network Journal* was the first, we don't have anything in the Nexus conferences about Egypt, of all things...

RACHEL FLETCHER: ...and vernacular...

KIM WILLIAMS: ...and vernacular. We don't have any native American architecture. Really what we haven't covered is vast. This is an on-going process. I really want to make a big archive, and I'd also like to create an environment where even if there's one poor soul in China who is making studies, I want him to have a place to publish.

CAROL WATTS: I think that the *Nexus Network Journal* with its presence on the web is going to be the most important for giving a more global participation.

KIM WILLIAMS: It helps a lot. The response has really been international and not just from a native English speaking group.

CAROL WATTS: Okay, I think it's exactly 6:00.

ALL: Applause!

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