Minutes from the
Human Research Program (HRP)
2014 Integration Discussion Session
Behavioral Health and Performance SRP, Bone and Muscle Risks SRP, Cardiovascular Risks SRP, and Sensorimotor Risk SRP

December 18, 2014
Afternoon Session

Magnolia Hotel
Houston, TX

Agenda – Afternoon Session

1:00 pm – 2:30 pm **Integration Discussion with Chief Scientist**

- **Evaluate the existing cross disciplinary integration as documented in the Integrated Research Plan (IRP) located in the Human Research Roadmap (HRR).**
- **Identify existing or needed integration already identified by the HRP Elements, but not yet well defined within the IRP.**
- **Identify areas of integration that are missing.**

2:30 pm **Adjourn**

Overview and Charge to the Panel:
HRP's mission is to reduce the risks to human health and performance during long-duration spaceflight. The HRP Integrated Research Plan (IRP) contains the research plans for the 32 risks that require research to characterize and mitigate. From its inception the "integrate" aspect of the IRP has denoted the integrated nature of risks to human health and performance. Even though each risk in the IRP has its own research plan and is tracked separately, the interrelated nature of health and performance requires that they be addressed in an integrative or holistic fashion so that the connectedness of physiological systems within the human body and the integrated response to spaceflight can be addressed. Common characteristics of the spaceflight environment include altered gravity, atmospheres, and light/dark cycles; space radiation; isolation; noise; and periods of high or low workload. Long-term exposure to this unique environment produces a suite of physiological effects such as stress; vison, neurocognitive, and anthropometric changes; circadian misalignment; fluid shifts; cardiovascular deconditioning; immune dysregulation; and altered nutritional requirements. Expanding cross-disciplinary integrative approaches that synthesize concepts or data from two or more disciplines would improve the identification and characterization risk factors, and enable the development of countermeasures relevant to multiple risks. Cross-disciplinary approaches might also help to illuminate problem areas that may arise when a countermeasure adversely impacts risks other than those which it was developed to

mitigate, or to identify groupings of physiological changes that are likely to occur that may impact the overall risk posture.

In 2014 HRP embarked on a pilot study that combined four SRPs (and 12 HRP risks) - Behavioral Health, Sensorimotor, Cardiovascular, and Bone/Muscle - specifically to discuss cross-disciplinary integration. The points outlined below were suggested to seed the discussion, within the bounding constraint that research plans must be feasible and relevant to the HRP mission. While these were suggested starting points, the overall guiding principle was to allow free discussion from panel members on any aspect of integrated research that they felt was important.

- Existing cross-disciplinary integration as documented in the IRP (HRR).
- Existing or needed integration already identified by HRP, but not yet well defined within the IRP.
- Areas of integration that are missing.

The transcript of the discussion in this integrated session follows in this document. This session was a departure from the conventional SRP meeting in that discussants were not required to restrict their comments to an existing evidence report or research plan. Rather, they were encouraged to think more broadly and to suggest research areas or approaches that HRP might not currently be considering. Commensurate with this brainstorming approach, and also unlike conventional SRP meetings, a formal report from the SRPs was not prepared, nor was a response required from any HRP staff to address points made in the integration discussion. The HRP Chief Scientist would make a determination, based on the discussion and transcript, as to whether or not to pursue any of the points raised.

Transcript

The following is a transcript of the recorded integration session of the Behavioral Health and Performance (BHP), Bone and Muscle Risks, Cardiovascular Risks, and Sensorimotor Risk SRPs. The meeting occurred at the Magnolia Hotel, Houston, Texas from 1:30 P.M. to 3:00 P.M. Central Time.

Introduction – M. Shelhamer (HRP Chief Scientist)

A couple of logistical issues; there is a transcriptionist here who is going to attempt to get everything down so that I can see all the great wisdom that comes out for the next hour and a half, or so. There are also microphones around the room. This is being recorded. So, for better or worse, you might want to be aware of that. Also, find a microphone if you plan on making an insightful comment, if you can find one.

We put a fair amount of thought into how exactly to organize--we are on the telecon as well--this particular session. We would like to have everybody from across every different discipline altogether in the same room and all the SRP members, that is not a great way to encourage discussion. So we picked a few key people from the SRP, from each of the individual SRPs to actually sit at the table with other people arrayed around the periphery, that does not mean that these are the only people who should be speaking, the ones at the table. And I also do not want to make it such that there is an audience here, in the back, around the edge of the room waiting

for brilliance to come out of the people who are sitting at the table. Everybody should participate in this, please.

This is really a departure from what we do with SRPs, as you probably have sensed already. Typically, when an SRP meets, we want you to adhere to an agenda that we have dictated through our research plan, our evidence reports, and really judge that and keep to a kind of a programmatic structure for us. Here, anything goes. We really want some brainstorming here. Do not worry so much about our programmatic structure; gaps and risks and tasks. If you come up with good ideas that are compelling, we will figure out how to get them into the program. We will do the task and gap and risk arrangements, if necessary. So, again, it is an experiment. So welcome to my experiment.

You have seen already through the discussion right here, we already have some areas of integration that are identified, some of which we are already pursuing, some of which we plan to pursue. Those are fair game. We can start the discussion with some of those areas, but what I am also hoping we can get out of this discussion is whether or not there are general principles for looking at integration. Is there, rather than identifying a few key things that are ad hoc that might be appropriate for today's current state of knowledge, is there a systematic approach for which we can use in the future to identify areas of integration. And in particular, I will just throw out one: the area of, the idea of resilience; when you have the human body or a group of individuals in space, all the different systems work together to compensate for perturbations, some of which we have not yet identified for a mission to Mars. Something unexpected is going to happen, and yet when things happen on short-duration space flight, the body and the team of astronauts re-organizes itself appropriately, compensates, moves on. Are there ways to assess that ability of resilience, which is a multi-disciplinary in the grid of process, and are there ways to enhance it? So I will just leave that as one touch point, before I turn it over to Dr. Gregor, who has graciously and somewhat bravely agreed to be the Chair for the integration session. Thank you.

Introduction – R. Gregor (Bone & Muscle Risks SRP/Integration Discussion Chair)

Here we go with the experiment. First, just a few comments, before we get started. We have to be done by 2:30, so we have a time delay in here because of flight schedules and other things. The spirit of the discussion, and it should be a discussion for everybody in the room, which Mark has already stated. I completely agree with that and I think, actually, we all agree with that. Everyone is important here, everybody's opinion is important. What has struck me so far in this meeting is the levels of integration that already exist. At the levels of integration that already exist, and it brings to mind the issue of complex systems, plasticity, resilience, something goes down in the human body and something else picks up the slack. Something fails to a certain level, or is constrained to a certain degree and other parts of the system pick up the slack. So that is kind of the way I approach everyone in this room and the different SRPs and the way we look at how we can integrate. I also look at it as not just collaboration, you can have people in one room who do not really integrate their ideas but kind of talk to one another and collect data together maybe to answer either their own question or a higher-level question, but I look at integration as indeed that higher-level is the next step in questions not just collaborating but actually going to the next level. And I have seen a little bit of that also, we have all shared these ideas and I have seen a little bit of that as well. So I think I would applaud the group in terms of

making those efforts. It is even applied to the last talk about teams, people, interacting, well, systems have to interact so it is, we all know it is pretty complex and we all also know it is really interesting stuff, I think that is why we are all here. So, in this theme of integration and everyone is important here, I would like to maybe just address a couple of things that were proposed to me that we may start as touch stones, just to get the conversation going. We have already documented these existing collaborations. We have already documented them to a certain degree. Actually, larger than I thought it was going to be so I was glad to see that. Identified existing integration, collaborations, you have also identified needed integrations, and collaborations. People have made statements, I forget who exactly said it but they said, I have been doing this but I would love to do that with somebody else. So the energy and the interest is there, that is what we are here to share. We are not here to talk about experiments, we are not here to talk about, as Mark said, gaps or tasks or things like that. I kind of want to keep it up here, in terms of a little bit higher level discussion about how we can do this, what is the best way to do this, what do we have existing in front of us in terms of structure? We always need some administrative structure to provide infrastructure to allow for individuals to integrate and share common goals. So I will start and actually leave it with that and maybe just ask people to raise their hands if they have something that they want to say at this time and I will start with the people here in the center, but I am going to be looking for outsiders, too, and try to keep everybody in the fold. My job, besides ending on time, my job is to get, as I see it here, in this next hour and 10 minutes is to get everybody involved.

Comments/Discussion

D. Krummen (Cardiovascular Risks SRP)
I think I just wanted to start the discussion with just an early idea. If we want to encourage collaboration, one way to do that might be to issue risks or acknowledge gaps that are themselves collaborative. I mean, we are here because of our specialty, and our gaps map to our specific knowledge base. But if we instead issue a gap that requires collaboration to solve and multiple PI programs to address, then that itself will programmatically encourage collaboration outside of these relationships that we develop or chancely develop here.

R. Enoka (Bone & Muscle Risks SRP)
I had a very similar thought. In listening to the presentation the last hour, I was quite impressed with the existing interactions between the different groups, but in trying to understand the value of such interactions it was difficult to determine, because we did not know what were the questions that were being addressed. So, I think if we, I, agree with the concept here, that if we think in terms of what is the knowledge being gained by having these interactions, rather than just ticking boxes and say we interact with this group here, what are the, what are the advantages of these interactions.

D. Krummen(Cardiovascular Risks SRP)
On that same note, collaboration is something that is desirable, but it also has costs, potential decreases in efficiency, so that should be acknowledged when these ideas are undertaken. Also, you can defer responsibility like when you have multi-PI investigation. PIs can potentially defer responsibility for gray areas, and then loose efficiency in those aspects, so the benefits, of course, probably outweigh the risks but the risks need to be acknowledged and potentially addressed for

these collaborative projects. Furthermore, I think someone at the top needs to prioritize the collaborative efforts, as to what is the highest yield for the potential mission.

R. Sumner (Bone & Muscle Risks SRP)
Actually, that comment, just, I jotted something down here. I think there is almost a paradox in that the science needs to be a little bit top down, like you said. Somebody needs to prioritize. And what really works in biomedical sciences almost the opposite. Investigator initiated. And the people that are really good at it figure out how to do the really key interactions either at their place or with other institutions, so, I think if there is some way to make it easier for scientists in the country to look at this and figure out what could I do and who do I know where I could start answering the questions. It is a kind of a delicate balance between those.

D. Krummen (Cardiovascular Risks SRP)
I think the difference between the NIH and NASA is, the NIH says we just want to improve human medicine. NASA says we want to take people and put them on Mars. So that is much more different than this nebulous idea of improving human health. So, I think someone has to take charge of that and run it from the top.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
What struck me was, it seems to me, that the need for infrastructure within this organization is recognized. And that infrastructure should provide some direction, but I do not think top down either, but some direction, but allow interface among scientists that have creative ideas which then, of course, as those begin to grow, you modify the infrastructure. You have some other directions, you have things tweaked over here, or tweaked over there, so I think NASA is taking a big step forward in recognizing there is a need for this infrastructure. To provide directives, though, they should, come, I think, from us, that is kind of why we are here.

S. Herdman(Sensorimotor Risk SRP)
To provide those directives, though, somehow people have to know what is available. I mean, I think everybody who sits on these committees is well-aware of how massive the amount of information is, and the amount of research projects, not just in our own individual areas but if you start looking across the board of all the standing panels, and somehow people need, who might want to collaborate, need to know about the availability of the other expertise across all these different areas. And I do not know how you solve that, but, because it is almost unimaginable to me that you can handle that, but it needs to be done.

J. Caldwell (BHP SRP)
Well, I think to that point I wonder how often everybody in these different groups gets together and sees what each other is doing. Because I know when I worked in the lab, somebody could have blasted the other end of the building off, and it would not have affected my life, unless it threw debris in the aisle, or something. So, I mean, there could have been some great stuff going on in other divisions, there could have been some synergistic relationships there, but I would have never known that, because we travel basically in different circles, even though we work in the same organization.

S. Zaccaro (BHP SRP)

To that comment, there is a sense somewhat of silos, here, and not a lot of connectedness. And I am thinking of the teams area. My next set of comments is that there needs, to do some of this integration, there needs to be more complex and deep conceptual framing. As I listen to all of this, in the last couple of days, I hear, for example, that there are individual physical risk factors; cardiovascular, bio, muscle, and so forth. They presume we have some tie to individual psychological risk factors, and we can make that case very easily. But then when it comes to teams, I almost hear a model of, well, if you sum the individual risk factors, there is your team risk factor, or, somehow, if the individual is affected, then the team will automatically be affected. Well, team theory is more complex than that. And I think we need some conceptual framing that says, first of all, how do these risk factors, for example, influence particular elements of teams, how do individual risk factors combine, some model, an averaging model is basically conceptually lazy. There are multiple models out there that talk about ways individuals combine into collective work. And I know the teams people know, but also the explanatory mechanisms. I have heard a lot of people say, well, this will affect the team, and I read this in the proposals, but no examination of explanatory mechanisms, such as motivation. For example, when you have an individual risk factor that rises to a certain level, effort allocation models will say that individuals will allocate their personal effort resources away from the team perhaps, and more toward individual care and individual tasks. Well, that is a mechanism by which you can connect those to what happens in teams, as a conceptual frame, there are many more out there and you have smart scientists who can figure this out, but I do not see the conceptual framing that would help an integrative effort. And I think some thought has to be given to that, because otherwise, you are picking low hanging fruit, you are saying well we are going to collaborate in an additive manner, where you put on measures together, or we will just say, individual health will affect team health, or something like that, and I think we have to do better than that, if we are going to have this meaningful innovation.

J. Krakauer (Sensorimotor Risk SRP)

I would like to add to that, I completely agree. I was going to say something very similar. Just two things; integration and collaboration are not synonyms. Having people collaborate and collect data and then have those boxes, like we saw, a few too many, I think, leads to a kind of commentarial explosion, which is going to simply exacerbate another problem that I will bring up in a minute, which is how low-end these studies are. So, you have low-end studies already, you start cross pollinating across these boxes you have even lower end, and it becomes even more difficult. Integration really means sort of weighting of data, in other words, if you want to enhance performance, you ask, well, what variable is going to weight more towards the performance, is it going to be how hungry they are, is it how sleepy they are, is it, and then you want to find some way to differentially weight these variables with respect to the outcome measure. That is different from wanting to maintain the health of these astronauts over time when they come back. If you want to do integration, and I completely agree with you, you need a conceptual framework, you need a model. Model-free data collection and filling boxes versus a model-based attempt to understand how these data are going to integrate in a weighted fashion are completely different things and I have not heard any discussion relating to that distinction. And then just maybe I may say it now, Susan and I were discussing in our study section the fact that the big systematic structural problem that we have detected is that you are forced to devise new measures and learn new things and apply them simultaneously in these NASA programs. When really, of course, what you would really like to do is have a large and validate a measure

and do it serially and then say I believe this measure, I know it has test/retest for reliability and now I am going to apply it to this population that is so low-end that I am just going to have to trust my measure, that is not what is going on here. So, one thing that is sort of similar to the idea of having a conceptual framework, is there has to be a framework for how to do low-end studies, because I have to say, my belief based on what I heard, with a few exceptions, none of these studies are going to be reproducible, the measures do not have test/retest reliability done beforehand, and so the job of applying these low-end findings to new individuals in a feet-forward manner is going to be disastrous. So, something has to be done to more systematically address low-end studies, reproducibility and reliability of new measures that are made on the fly as you investigate these astronauts. I have not heard any discussion in relation to that, either.

G. Leon (BHP SRP)
Well, in our BHP area certainly reliability and validity of the measures that we use are key to our discipline, and so this obviously varies according to the different areas that we are talking about here but I really disagree with you in terms of the BHP area. I would like to talk a little bit about a conceptual framework in a different way in terms of what Mark just mentioned, the idea of resilience. This really resonates. We have talked about individual profiles, individual differences. The other side of it, the issue of low-end studies. We will be dealing not with large populations but with a small number of people and I think that a paradigm in terms of looking at individual differences and what we can learn from individual differences will be helpful, so as a conceptual framework, I agree. I would like to throw out this idea of resilience as an NRA topic. To ask for multi-disciplinary proposals all of which, in some way, cardiovascular, sensorimotor, BHP, I mean, the whole gamut, would evaluate in some ways, work together in an integrative way, in terms of a specific topic, and resilience is more than a topic, it is a conceptual framework, and this would be my suggestion.

S. Zaccaro (BHP SRP)
If I can jump in on that, I think resilience is an excellent example of where you cannot just sum the individual to get to the team, because the notion of individual resilience and the conceptual models that drive that work are very different from the emerging area of team resilience and what that means. I think that you already have a paper that I am aware of that starts to make that distinction. But, first of all, you cannot apply the same conceptual frame to individual resilience as you would to team resilience and you still need another conceptual frame supporting your point that links individual resilience to team resilience, and that is where the conceptual--you can go out and do research and call for research but unless they are giving you novel conceptual frames that go beyond just what is in the current literature because it is not there yet, these are new areas, that one is at least, team resilience, relatively new, then integration becomes more collaboration than integration to use your distinction. I agree with your overall point about measures. I absolutely agree with that. I think, however, in the BHP, some of the work, I have seen evidence that validates it just the way you said where they start with big populations and bring it forward, like some of the…the work that they do.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
So, let me just ask a question. Let me just ask a question. Integration is a very broad and diffuse term. When we talk about integration, are we talking about the integration of physiological systems in response to a perturbation, like microgravity? There is a great deal of discussion here

that is devoted to that. There is also the need to talk about integration. And I am not talking about independent things, either. They are very interdependent. Is there a discussion here that we need to have about integration and teams because the behavioral aspects of these people in a confined space for an extended period of time, they themselves will have their own individual problems which then becomes a team problem which then becomes everybody's problem. One of the questions I had when I first came here was so what are we going to define or how are we going to apply or how are we going to put in a box the term "integration". What are we referring to? There are already two major categories that we have applied it to here; team interdependence and integration of like a seal team or something. They have to be together, right? These astronauts in microgravity have to be together, that is a tremendous challenge. Each of those cases is offset by individual response to a war environment or a microgravity environment and we have a million examples of that. I think one of the things that I would like to maybe have a discussion about is the clarity between the cross talk between those two. They are interdependent, they are not independent of one another, one affects the other. Personal health gets affected by the team, so it is a matter of structuring our conversation maybe about, what do we mean by integration and how do we want to think about that and in what context do we want to think about that, because I have seen two very important contexts, so far.

S. Zaccaro (BHP SRP)
I think in my earlier comments I was trying to get to some of that and say to integrate, what we know about intra-individual systems, how do you link that with interpersonal team and multi-team systems? And I think that is where the conceptual framing has to happen. You are absolutely right, and you have another component. We talked in our group about, you talk about long duration missions but not long duration teams, and we do not know a lot about, I was surprised to realize that, we do not know a lot about teams that stay together but I think the impression is they are going to stay together and work together in tight environments for multiple years. What does that mean in terms of the evolution of the team and the individuals in the team? So, I think that is what I was trying to get at with integration in the sense that there needs to be some new conceptual framing that talks about integrating intra-individual systems both physical and psychological with interpersonal intra-team/inter-team systems.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
Anybody out there beyond earth's gravity want to talk about that? Yes, thank you.

Unidentified Male
I was musing about teams and networks of science and collaboration, and it occurs to me that there are rich sources of research literature on teams from across the campus from historians. We look at voyages of exploration and discovery and log books where voyages are long gone from the home base. We may be able to learn some revelatory information.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
Anyone comment? We are pretty quiet at the end of a day and a half. I guess we have to get jazzed up for another 45 minutes. Yes. Thank you.

Unidentified Male

There is, I think there needs to be a task direction initially in order to generate useful integration. Many of the tasks that we have seen have been divided down into very small individual categories, the better to scientifically measure them. And in many cases that is quite appropriate, and as you said we need to get down to simple things and get reproducible data, and we do not want to stop that, but that certainly does not encompass the overall goal. To give an example, say you want to land on Mars, and something goes wrong. Now you develop a scenario and say, how are we going to get people with orthostatic intolerance, with difficulty moving and placing things on dials as they go from zero gravity to gravity that exists, and how do we get them to work as a team? Now that is an entirely different scenario. If you say we have the basic measures on orthostatic intolerance on team work, etc., worked out, now we need to address the overall question. That overall question then generates a natural goal towards team investigation. And you are no longer saying, is a person going to be on a tilt table and develop dizziness, you are saying, is a person sitting in front of a computer monitor trying to get it to boot up going to have an emotional reaction, and his blood pressure will either rocket sky-high and orthostatic intolerance is not a problem, or he will have a vasovagal reaction and his blood pressure will crash. You are not going to find that out until you develop these team goals and tasks. And so, that is just an individual example, but I think the overall idea is, if you want team work, then you have to ask team questions. The team questions, I think are now ripe to be asked. There is so much basic data that we have heard with very good measurements, and now, those need to be integrated into real-life examples.

J. Krakauer (Sensorimotor Risk SRP)

So just a little comment about that, I mean, I remember being in a meeting early this year where somebody was talking about the stock market and trying to predict how the stock market works, and how individuals buy and sell, and it was very interesting. He said to us that 400 years of data have been collected on the stock market and very little important predictive data has come out. And in fact, what he is suggesting and is doing is experimental economics. You do simplified experimental versions of buying and selling and you actually do perturbation experiments, you actually check. And so I am just trying to understand the difference between collecting a lot of data and then trying to sort of make a determination as to what a good team setup is versus doing basically knock-out experiments, you basically put the team together under simplified conditions and you take somebody out, or you strap their legs together, or you do something like that, and you do some experiments. So I am just trying to understand are we talking about observational studies which we know in medicine have not turned out to be true, or are we doing experiments where we actually manipulate scenarios, knock people out and in, and see what works? Because I think a lot of data collection, like the stock market, and then decide what the best team setup is going to be, is not going to work. So, are we suggesting, as I understood you, that we do team experiments, and manipulate individuals and their traits to see what happens, or are we just going to collect loads and loads of data and then post hoc try and work out what is best?

G. Leon (BHP SRP)

Some of these experiments are already ongoing with the high seas analog, for example, where there are emergency situations, stressful situations that are set up and then to evaluate how the team is responding to that. You certainly raise a very important point and there is some ongoing research on that already.

G. Thomas (Cardiovascular Risks SRP)
And I think there are a lot of parallels to what we struggle with in biomedical research today. All of the reductionist experiments that have been done, all of that activity that has produced incredibly new knowledge, but trying to take that back to an intact analog, an intact being has proven to be very difficult, and to integrate all that information. It is the same kind of question. And I do not think we have solved that for our day-to-day lives so it is a really interesting discussion that could have ramifications beyond what NASA wants to do.

G. Leon (BHP SRP)
I really like the fact that we are talking about teams, because, really whatever system we are looking at it will affect, in one way or another, how people interact. Not only in terms of the work performance but just in terms of the social interactions, if someone is not feeling well or someone is dizzy, etc., etc., so I am very pleased to hear the discussion formulated in this way.

Unidentified Female
I would like to make the observation, I think integration exists at different levels and should exist at different levels and what I mean is, we, at one level, we need to make sure when certain studies are undertaken and they are collecting information, for example, on VIIP, and they are trying to find the ideology of VIIP, please include a cognition measure as part of your study design, because then we can get more information and we can understand more realistically about what the impacts are to the individual's behavior. So that is one level of which I think we need to foster greater integration, and that can be done pretty easily through our NRAs, and in putting those kind of requirements into the NRA, and that requires some healthy collaboration and more meetings to do that kind of stuff. I think we can go a little bit another level and we can have some multi-disciplinary projects, where you have the IH mile program project or NASA has several times used n-scorts, they do it in radiation, but you have an interdisciplinary team looking at a certain, something that is mutually beneficial, like a scenario that was suggested, that is a very good idea, I think. So that is another level of integration that I think you could do something, get some traction from. And then I think though to really bring everything together, all of these parts and all of these pieces into a whole is really tough, very, very, very hard, and that requires some real critical thinking about how to do that and how best to do that. That is the important piece, and I do not have an answer for that one. I think, though, that the artificial gravity task that Peter talked about on Day 1, where we are trying to look at artificial gravity as a way to equip the Station so that they do not have the microgravity problems but that has multiple system effects and benefits, so that is an integrative project that maybe would work at that level or other higher level. So, those are just some of my thoughts.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
So, maybe we know this needs to get done, the big dilemma here is how do we do it, which is always the case. We have an SRP that naturally marries bone and muscle. It is one SRP. I am not suggesting we combine SRPs necessarily, but there are other examples from anyone here to say that if you were to join with one or two other SRPs in developing an integrated set of tasks from an integrated set of lack of knowledge, gaps in knowledge, other examples, because there have been some already presented and the deal is, at what level are those interactions, do they come from integrated hypotheses about here is a gap in knowledge, we hypothesize if we do this

we will get that, but not just for bone and not just for muscle, not just for the central nervous system or the sensorimotor system but for bone, muscle, cardiovascular system, so you know where I am going with this. So I think maybe how to do this, is something we may want to try to discuss right now to get moving on some ideas that are workable. We understand the problems, probably better than anybody. It is not that, it is so what do we do about it. And that seems to be, we always come to the impasse, so let us not come to this impasse, let us, somebody poke a hole through it and say, okay, this is what we are going to do, this is what I think is a good idea. We are experimenting. I have done bad experiments before so we do not want to do it again but we are willing to take the risk. So does anybody got any ideas? Yes?

Unidentified Male
Thank you. This actually gets right back to where you started talking. And I am with the Walter Reed Army Institute of Research. We are a biomedical research institute with a mission. And, so we are unlike NIH in that respect. We do not have a broad mission; we actually have a fairly narrow mission. And I think that collaboration is in fact the highest form of integration. Every three years we get a new commanding general and there is this top-down directive to collaborate. To collaborate with the Israelis, collaborate with the Navy, and it never works. Because that is about the level of instruction that we get. But what does work and what has always worked, and it seems to be the only thing that works is what John Caldwell suggested, let us get the scientists together talking. They will actually come up with a hypothesis, they will come up with the framework, and then, at the higher levels, it either gets, yes we will fund that or no, we will not. But, it is always, all the successful collaborations, at least at our institute, and I think John will agree, have been from the bottom up. In fact, that is why they, we used to be in all these separate buildings. They built a new building and put us all in one building and collaborations went through the roof. Just because we talked. So, as John suggested, the way to do it is to get more interaction among scientists, who are not, by the way, always anxious to do this, because they feel it is taking away from their time and their lab. But if you do get them listening to each other, like I did not know about the, or I did not think about the relationship between sleep loss and bone loss with hormonal intermediate step. I thought they had nothing to do with each other; not going to integrate there. But I just learned something and ideas, as a scientist they start coming to you; yes, here is how we could manipulate that. So that is all I want to say.

S. Zaccaro (BHP SRP)
I think it goes back to asking integration questions to get people to start talking together. Because the way the questions are phrased to us, they are more silo and focus within an area. So for example, you just said I did not know how cardiovascular, bone, and so forth was related to one another. I had not thought much before I was in a room with people here how cardiovascular and bone and so forth, and sleep, was related to team functioning, so now I am thinking about it, and I am not an expert in that area, so if I am talking with an expert, and we are working on the question together, out of that comes, maybe, hypotheses. So as a starting point, do you phrase your research questions in an integrative way? I think that is what some of the other people are getting at. I am well aware of the issues of collaboration across discipline that I think you were alluding to, but I think, you asked how do we start, but it is like getting these areas together, and fostering integration, integrative research questions, and say how do these areas relate to one another?

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
So we agree with that. How do you reconcile that or can you provide some ideas related to the need for a framework to do that? So we are talking about a framework to allow this to happen.

S. Zaccaro (BHP SRP)
Oh, you are talking about administrative framework.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
What you just talked about.

S. Zaccaro (BHP SRP)
Well, I was talking about a conceptual framing. I'm not sure what you are asking.

M. Shelhamer (HRP Chief Scientist)
Since I am getting the report, I am trying not to contribute too much, but what I am trying to reconcile here is the point you just made about best integrative projects, collaborations come from the interactions among scientists. They do not come from a directive from the top. I recognize that. And yet, just a half-hour ago we were discussing the need for a conceptual framework, how do you reconcile those. You get scientists to collaborate, generate their own collaborations but yet feed into a conceptual structure. Not a programmatic structure but a conceptual, intellectual structure.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
Let me get Lori involved, go ahead. Stand up, please, so we can hear you. And then David, we will go to you.

Lori (NASA JSC, Aerobic and Muscle Risks Portfolio Scientist)
So then this is not necessarily my original idea but we have talked about this and I kind of wanted to throw it out to the group. Perhaps one conceptual framework could be an integrated countermeasure. And we have talked about, ok, in 10 years we need to float our best plan, and so if you got people talking now, bring on your best exercise program, and what is your best diet, and what is your best sleep program you have got, and what is your best team work thing, and your best, whatever. Go through it all and have everyone start talking about, can you be ready in two years, or three years, or, I do not know the timeframe of this but, to bring on your best part and then we are going to have to put this all together, in a kind of dream project before Station is over, is try the integrated things. So, you eat the best food, and do the best exercise, and get the best sleep, and put all of our best foot forward and actually try it all together. And if people start thinking about that early on, maybe that could be a conceptual framework for integration that still--you have to encourage the individual scientists and to work on the expertise in their area because that is what they get excited about and passionate about but the bringing it all together is what we actually have to do someday.

D. Krummen (Cardiovascular Risks SRP)
I think my thought was very similar to Lori's. I am not sure this is a complete answer to the problem but science occurs when the right people recognize a need. And they think about it then you wrestle with it a little bit then you come up with some ways to address it; sometimes the

ideas work, sometimes they do not. Ways to get the big projects done is to have big groups like us get together and say, ok, we want to do "x". Cardiovascular system, are you ready to go? And if the answer is no, you need to address this. And let us say that issue is addressable within cardiology fine, it does not require integration. Often times it does, like antigravity. Antigravity, I am not suggesting that that is or might not be the final answer, but that is such an integrative problem. It requires engineering, it impacts bone and muscle, sensorimotor team, everything so like that sort of, if you wanted to use that as a countermeasure, that would by its very nature of complexity require team effort. So, meeting as a group, saying here is our task, where are we now, individual people are you ready to go, and if the answer is no, sometimes it would require collaboration and sometimes not. And I think that was for—

S. Zaccaro (BHP SRP)
I want to go back and respond to what I heard earlier. How do you get a bottom-up approach and a conceptual frame? I do not think I meant to say a conceptual frame was imposed on people who then work on the problem. I think if you ask integration questions and do a process of science that I think I heard you say so when you ask an integration question and you get a bunch of scientists from different areas working together, hopefully, out of that work comes a set of hypotheses in a conceptual framing. So just to be a force to think about, how sleep is related to teamwork. I am scribbling models and stuff, and I am not an expert in any of this, but if you got someone who knows what they are talking about or thinking about in this area, then you might start to bring together conceptual framing. Pulling together some of the scientists I know you already have, and from that a model comes and then more sophisticated questions come out of that, more sophisticated measures maybe, but I do not see a frame-imposed top-down and a process bottom-up, I see asking the right integrative questions will give rise to both models and measures and more related research questions.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
So the conceptual framework will emerge from that. That is what you are saying.

S. Zaccaro (BHP SRP)
It is hard for that kind of conceptual framework that I think you are asking for to emerge from a single perspective. So, if you ask a team scientist to talk about how bone, muscle, and stress and sleep is related to teamwork, I do not think they will give you the kind of integration you want, but I think if you get people from different areas, and that is a challenge in itself, to argue about that question, from there you may get the conceptual framing.

J. Krakauer (Sensorimotor Risk SRP)
Just how you might, everyone has a fuzzy null, in other words, the fact that we have the different groups here is already a hypothesis. You have already said you think bone and muscle is important, you think sensorimotor is important, so that is a hypothesis. But all that is being suggested is that you have to go beyond the parts which we are already at and now you need to put some flesh on it by knowing what the processes between the parts might be and have some kind of articulated null that should be tested. Because either you articulate the null and all come to agree with it or you just walk around with one in your head and do not even know you have got it, right, so the conceptual framework can even be brought out in the open, articulated and worked on along with the parts, or everyone walks around with the fuzzy null and they do not

even know they have it. So, that is what you have to do. And you begin to say, ok, what is our null with respect to the interaction between sleep and teamwork, or whatever. And you then have ways to test it. So it is not some sort of imposition from on high. And there are many examples, the Manhattan Project, Bell Labs, Sante Fe Institute. Of course there is top-down programmatic and conceptual frameworks and people are allowed to play. There is not a contradiction between serious play amongst creative people and there being top-down articulation of an overall view either programmatically or conceptually. I think it is very simplistic to think that they are contradictory. They coexist.

Unidentified Male

I have been following the conversation, I am hearing, well, first of all I want to say what NASA seems to be really good at is splitting. Breaking a complex problem down into its components and trying to then solve the components. What I am hearing is that what NASA is not so good at is integration, is in pulling things back together. It seems to me that you need three things: you need content, and I have already heard some content, resilience is one, sleep performance is another one, team maybe, you need a content area. You then need a process of actually implementing the how to. And then the third thing you need, incentives. And obviously incentives would be proposals that basically, you are giving people support to do something to solve a problem for you. So it seems to me that we have heard a couple of content areas and I think that there is also some discussion about what the process should be. It cannot be a one step, it cannot just bring people in ones and then expect ok, so now we have integration. I think what it is, is you have to think about how do you repeatedly implement people getting together. So, for example, the lead scientist in the different areas. Maybe they should meet once a month, maybe they need to discuss what their portfolios are, what their issues are, and then they communicate with the rest of the scientists that actually work as part of their portfolio. Maybe there need to be conferences, and these are all just pop out ideas. And the incentive structure, that is even more vague to me, obviously you guys know much more about, but you need to set up an incentive structure that incentivizes collaboration. If there is just one PI from one area, you are not going to find that person. You are going to fund that person if at least two areas work together.

J. Caldwell (BHP SRP)

Yes, that incentive part, I think, is so important, because right now if you tell me, ok, well your job is to solve these problems related to sleep, then is it in my best interest, in my team's best interest to clearly define several objectives which I can then go out and do and then check off the block at the end of the month, so, and that is kind of a top-down thing. I am not really incentivized to go and talk to these people over here who are in areas that I do not really know very much about. I do not think there is very much of a, that is kind of a managerial role, I think, is to make that important to the individual performers.

D. Krummen (Cardiovascular Risks SRP)

I would agree that the incentives, a funny anecdote is, even from NASA is, the lunar module, in '67 it was overweight and they gave a 10,000 dollar bonus for every pound that they could take off the lunar module. I guarantee those lunar module engineers went home dreaming about how

to make the landing skids lighter because of the incentives. Human nature is so amendable to that, as a way to direct thinking. I think that would be very beneficial.

S. Zaccaro (BHP SRP)
I am putting myself in your place and I am thinking, boy, I underestimate, I agree with all of this, and I recognize you may be underestimating some of the challenges of cross-disciplinary integration and functioning. I recognize that. I suspect that there are lots of best practices out there for trying to do that. I just keep getting reminded from several comments of a study by Neche published in Science in which he looked back at research teams all the way back, in citations, in publications, and he found that the most creative ones were the ones in which you had two people from different disciplines combining what was routine in their disciplines and out of that came something very creative. And that study, I heard that last year. It has fascinated me ever since and I think that is the kind of thing you want to nurture, at least as part of your overall, at least integration, part of your portfolio. I am not saying we move all the way away from functional and disciplinary both, but, I think to answer your question about how to foster integration that this would answer some of this.

S. Herdman (Sensorimotor Risk SRP)
So, Mark, were you expecting to get, the discussion about how to foster integrative studies, or were you expecting to get specifics of what should be done?

M. Shelhamer (HRP Chief Scientist)
Yes.

Unidentified Male
So one thing that has not come up with regards to structurally on this is how you form study panels then. If you truly want to encourage interdisciplinary, careful selection and cultivation of those study sections are going to be imperative. You can see all the time where interdisciplinary is often touted but when it gets down to the review sections in the study sections that sometimes is penalized for thinking creatively. And so I do not know how that challenge is addressed. I know we have some of the, whatever the term is, the scientific review officer equivalence for NASA here today and those are some things structurally that you may have to think about if you are going to not only craft some of these NRAs but then how do you recruit and get individuals that have that interdisciplinary feel to their evaluation?

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
I think of these student seminars you have in various places where you bring students in from, I am thinking of kinesiology departments, or integrated departments with lots of different experts and different areas, maybe each in their own silos, but you force your student to go to that seminar and take it for credit and they cannot just talk about their own area, they have to develop a question with somebody else in another area. So we are kind of doing the same here. We are not students, but we still are students, so it is a matter of pulling resources together, maybe in a seminar or some kind of workshop type of environment where you reward, however you want to reward it, and have them come up with some ideas that actually require the input from both areas or three areas or however you want to do that, but it is a conceptual framework that would maybe move us in that direction. Comments? Are we worn out?

Unidentified Male
I think it is just a practical matter, something I think goes across all the disciplines that are here and that is, and it worries me a bit, we have got a pretty good exercise capability on the current International Space Station, but I am told that that is too big and too bulky to have any chance of going on a mission to Mars. I think the provision for adequate exercise basically crosses all the categories of groups of research focus we have here. It is critical. I made a list of things that it is critical for. I could barely fit it on one page. It goes across just about everything that is here including moral, teamwork, astronaut safety, health, ability to do the job. I think if we do not have some type of exercise equipment that is doable for a smaller vehicle that we are going to be in trouble. And it is going to potentially compromise the ability to safely do a long-term mission. I think maybe working on development of a new suite of exercise equipment and capability, it is not the be all and end all as far as integrative work or collaboration but it is just one aspect of something we could collaborate on because I think that is critical and it needs to be done in the next 10 years before the Space Station is gone because I think it needs to be put up on the Space Station despite protestations to the contrary that it cannot be done. It can always be done if it is important enough to be done and then to compare it to the program that we currently have that we know works for at least several areas. I do not know the degree to which it has been tested for the behavioral medicine side of things. I know it impacts sleep, it impacts morale, it impacts function in a lot of different areas, besides cardiovascular, muscle and bone, and that I have a particular interest in. But I think it is really important that we look at developing a new suite that can go on a smaller vehicle. That would require collaboration with the people that are planning the vehicle, it will require collaboration with the people that deal with habitability, and it could give us the potential then to test that new suite of equipment as far as its impact on all the areas that we have here and compare it as a control to what is already on the Space Station, that we know at least in a lot of areas it works pretty well but will not be able to go on a mission to Mars. And that is just a practical matter, it is not as lofty a discussion as what has already gone forth here and that is why I held it to the end, but I think it is just one area that perhaps could benefit from some collaborative work among us all.

Unidentified Male
Yes, collaboration, cooperation, and integration, is a pull rather than a push. NASA is an ultimate interdisciplinary, collaborative, integrated agency, or at least we try to be. But it was because there was a task that had to be done, landing on the moon, that demanded multiple disciplines, all kinds of participation, integration of the effort, and working towards a common goal. And unless we explicitly state what the common goal is, what the needs are, and what the pull characteristics are for integration and interdisciplinary actions, it is just a matter of happenstance, when two people decide, gee, let us collaborate, there is no focused direction. And I think what we have to do is get a better overview of what we are really all about here. And that means looking at the pull characteristics of what the mission is going to be, and what we need to do to accomplish it.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
Yes, that is a good point. Other discussion? Yes.

Unidentified Male

To some extent I have to disagree with that. Because I think it is not unfocused. Actually when you get those two scientists together that that is the most focused effort you will get, less systemic. But that is actually the beginning of a conceptual framework, the beginning of the hypotheses, the beginning of the process by which a question will be answered even, although we have suggested that the Manhattan Project was top down, it was not totally top down, not by a long shot.

J. Krakauer (Sensorimotor Risk SRP)
I never said totally.

Unidentified Male
Ok, so yes, I will give you that there has to be at least agreement from the top, but many of the best ideas for how to solve problems come from the scientists again, and unfortunately it is happenstance that the two meet. But you can increase the odds of those two people meeting by having them get together and discuss things. I mean, we are talking about integration like that is necessarily a good thing. It is a good thing for some questions, not a good thing for others. It is not something that we should be aiming for just for the sake of integration. If integration is needed to answer the questions, great, but again most of those questions are going to come from the scientists, not from me.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
So, we have about 10 minutes. Go ahead. David?

D. Krummen (Cardiovascular Risks SRP)
I was going to make an overall comment. I am glad we are having this integrated meeting and to know that the treadmill that we have is too heavy to make it to Mars. Because all of our discussions assumed it was going to make it to Mars. I mean, this is a great example of; we are making assumptions, like the cardiovascular section assumes that we are going to have the ARED treadmill. I mean, that was a part of all of our, we are meeting our goals for cardiovascular fitness; we have got the ARED treadmill. It is too heavy. Now we have identified a problem. So we need a multi-disciplinary engineering group to design one that is lighter.

Unidentified Male
We are actually doing exactly what he said. We designed hardware that is 10 times, or in order to make it less big, we are going to put up on Space Station to test it out before we go, that is part of the integrated suite that Lori said, so we will have all the hardware up there, all the capability, but it will not be as big.

Unidentified Male
So, I am looking around the room and we are talking about integration in a limited size room but there is somebody who is not here, and that is anyone from the commercial space exploration industry. And what do we have, what are they up to, is there any communication, are we able to integrate knowledge? I would hope that maybe next year that might be addressed.

Unidentified Female
I can actually kind of, sort of, talk about that. I am the Element Scientist for Space Human Factors and Habitability. Part of my team actually does work human system integration requirements for commercial, for ISS, for Orion, APCV, and that is kind of the tie, to relate anything we learn from the research and outcomes, we try to be, in terms of standards, processes, tools to the Program, Programs, and so that is one of the key things we have been doing and we will continue to do. And actually, that is one thing that I was going to mention before you mentioned this is that when I want a challenge is today's focus is HHC and BHB, but there is close ties to my own…Space Human Factors and Habitability have that ability because at the end of the day, we try to come up with the requirements, looking at human limitations and capabilities and come up with the requirements to help to design the vehicle. What kind of requirements come close to the design engineers that is actually going to come up with the ray out with the…we talked about the …because challenge every time. The first question our teams are ask is what is the minim volume you want to live at? And if it is possible they can probably want to tell you they are going to strap it on his feet and send everybody to Mars all the way, strapped in…So, but that is reality, because it is a…space, right?...it is going to cost me much more. It is going to take…long, so there is a good balance, and that is where this can be comes in, where we do our research on product, often the goal is…as you know and understand human capabilities and limitations, how does it convert to a verifiable requirement that engineer can use it to design the vehicle? We cannot just say, where, here is the how much force we can apply, and how much greater force do we have, what does it mean to them? So, that is the challenge that we come up with is this identifying how do you impose how do you impact the vehicle design that is going to take us to the Mars? So anyway, I just wanted, at that level I just wanted to say, because I think there is a lot of synergies as the product ultimate goal is not only understanding… but then how do you provide that vehicle environment where you actually can live happily ever after and come back.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
And come back. Are there any final comments or questions that people have or…? Yes.

Unidentified Male
One final comment. And the cardiovascular section stated this to Mark when he was there is that, we thought the experiment here was very fruitful, even just having discussions over coffee in the morning, sitting down and having breakfast with some of the bone and muscle folks got us talking a little bit about the impacts of resistance training and how that is beneficial for bone and muscle but we are now learning more about intracranial hypertension and other areas where that countermeasure may be working opposite to some of those effects, and that cross fertilization talk probably would not have occurred if CV had only been here by ourselves, so I am sure you will be requesting and getting more feedback as to whether or not this experiment was successful but from my perspective, coordination may have been difficult, Tiffin, but it might be worthwhile to continue doing this. And maybe even designating a little bit of time to say, on this particular trip we really want to make a concerted effort for bone and muscle to work with cardiovascular. We are going to give those two SRPs an hour together at the end where you guys may discuss some of your synergies and keeping some of that in mind.

D. Krummen (Cardiovascular Risks SRP)
One last comment from me is that it would be very helpful from a human spaceflight research standpoint to have an up-to-date understanding of what our best concept of the mission is, from engineering, from orbital mechanics, from everything, so that we know because right now the problem is, ok, you got somewhere between two and eight months of travel out, somewhere between two days and a year on the surface, and then somewhere between two months and eight months back, that is a very wide delta for all of those different aspects. If we knew better, even if it changes, what our best concept is from those other disciplines, engineering, and the other ones that I named already, that would be helpful for us to address these risks even better.

R. Gregor (Bone & Muscle Risks SRP/ Integration Discussion Chair)
One final comment, from our discussions in bone and muscle is, we really would like to see reports, more comments, so you want to do more work? We want that information and like we ask for sensorimotor, we ask for some others that are final reports that actually tell us what you all are thinking in those other SRPs that is important to us, so at the very first get-go share this documentation. We do it pretty good now, we just want to keep doing it better and that was a comment we made, as well, it is just trying to gain some insights, try to address your comment for joint meetings, who would you want to meet with thing.

S. Herdman (Sensorimotor Risk SRP)
So, along with that line that we encourage you to just not share the reports between groups that already know that they would like to see another report but simply across all groups. If we had not sat down the other night, having a drink, and I started talking about medication and motion sensitivity, the whole conversation about nutrition maybe should be involved in that and see whether that is a solution, or help for motion sensitivity. You have to cross across all the groups.

T. Ross (SRP Meeting Administrator)
There are, just to let you know, the reports are available, but I know you guys do not want to go to the website. So, we will make, every year we put all of the reports from the current year on the research website but I know you do not want to go there so we will make sure you get all of the reports probably by, around, February 1. All of them are done…Kevin and I will send them to you, so you have everything, but all 13 SRP reports from all 13 of the SRPs are available on the website but we will get them to you.

S. Herdman (Sensorimotor Risk SRP)
Thanks.

M. Shelhamer (HRP Chief Scientist)
Ok, so I guess I get the final words. I was a little concerned going into this that I thought I might have a problem, we might have the problem that people would not be willing to think beyond their individual disciplines, and the whole hour and one half discussion would just be about, well, you and I can collaborate and you and I can collaborate, that clearly was not a problem here, which I really appreciate. I think people were willing and able to speak at a higher conceptual and programmatic level and I think part of that is due to the fact that the people on the discipline level were able to present a number of areas in which we already are collaborating and doing interdisciplinary work. So I think there is an indication that we already are doing

some of this. I would, please, welcome your comments on this, both in terms of areas of integration that might not have come up and also whether we approached this whole process correctly. If you got enough out of just having coffee and drinks together with people from different disciplines without having to have this session, that is fine. Tiffin's workload will be a lot less next year at this time. But if this was beneficial, it was useful to me, if this was beneficial, then we can do this. We can slice it a different way, we can have different groups next time, more groups; we can do it a lot of different ways. So I will be looking for your input. So, in conclusion, I really appreciate everybody participating in this experiment, thank you.

---End of Recording---

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Joel Dimsdale, M.D. – University of California, San Diego
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