

**HUMAN SPACEFLIGHT ETHICS AND OBLIGATIONS:
OPTIONS FOR MONITORING, DIAGNOSING,
AND TREATING FORMER ASTRONAUTS**

HEARING
BEFORE THE
SUBCOMMITTEE ON SPACE
COMMITTEE ON SCIENCE, SPACE, AND
TECHNOLOGY
HOUSE OF REPRESENTATIVES
ONE HUNDRED FOURTEENTH CONGRESS

SECOND SESSION

June 15, 2016

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CONTENTS

June 15, 2016

Witness List	Page 2
Hearing Charter	3

Opening Statements

Statement by Representative Brian Babin, Chairman, Subcommittee on Space, Committee on Science, Space, and Technology, U.S. House of Rep- resentatives	4
Written Statement	6
Statement by Representative Donna F. Edwards, Ranking Minority Member, Subcommittee on Space, Committee on Science, Space, and Technology, U.S. House of Representatives	8
Written Statement	10
Statement by Representative Lamar S. Smith, Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives	12
Written Statement	14
Statement by Representative Eddie Bernice Johnson, Ranking Member, Com- mittee on Science, Space, and Technology, U.S. House of Representatives	16
Written Statement	17

Witnesses:

Dr. Richard Williams, Chief Health and Medical Officer, NASA	
Oral Statement	19
Written Statement	22
Captain Chris Cassidy, United States Navy (USN); Chief, Astronaut Office, NASA	
Oral Statement	28
Written Statement	30
Captain Scott Kelly (USN, Ret.), Former Astronaut, NASA	
Oral Statement	35
Written Statement	37
Captain Michael Lopez-Alegria (USN, Ret), President, Association of Space Explorers-USA; Former Astronaut, NASA	
Oral Statement	41
Written Statement	44
Dr. Jeffrey Kahn, Professor of Bioethics and Public Policy, Johns Hopkins Berman Institute of Bioethics; Chairman, Committee on the Ethics Prin- ciples and Guidelines for Health Standards for Long Duration and Explo- ration Spaceflights, Board on Health Sciences Policy, National Academies of Sciences	
Oral Statement	54
Written Statement	57
Discussion	62

Appendix I: Answers to Post-Hearing Questions

Dr. Richard Williams, Chief Health and Medical Officer, NASA	78
Captain Chris Cassidy, United States Navy (USN); Chief, Astronaut Office, NASA	100

IV

	Page
Captain Scott Kelly (USN, Ret.), Former Astronaut, NASA	109
Dr. Jeffrey Kahn, Professor of Bioethics and Public Policy, Johns Hopkins Berman Institute of Bioethics; Chairman, Committee on the Ethics Prin- ciples and Guidelines for Health Standards for Long Duration and Explo- ration Spaceflights, Board on Health Sciences Policy, National Academies of Sciences	114

**HUMAN SPACEFLIGHT ETHICS
AND OBLIGATIONS:
OPTIONS FOR MONITORING, DIAGNOSING,
AND TREATING FORMER ASTRONAUTS**

WEDNESDAY, JUNE 15, 2016

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON SPACE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 2:43 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Babin [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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(202) 225-6371
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***Human Spaceflight Ethics and Obligations: Options for
Monitoring, Diagnosing, and Treating Former Astronauts***

Wednesday, June 15, 2016

2:00 p.m.

2318 Rayburn House Office Building

Witnesses

Dr. Richard Williams, Chief Health and Medical Officer, NASA

Captain Chris Cassidy, United States Navy (USN); Chief, Astronaut Office,
NASA

Captain Scott Kelly (USN, Ret.), Former Astronaut, NASA

Captain Michael Lopez-Alegria (USN, Ret.), President, Association of Space
Explorers-USA; Former Astronaut, NASA

Dr. Jeffrey Kahn, Professor of Bioethics and Public Policy, Johns Hopkins
Berman Institute of Bioethics; Chairman, Committee on the Ethics Principles and
Guidelines for Health Standards for Long Duration and Exploration Spaceflights,
Board on Health Sciences Policy, National Academies of Sciences

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

Charter

TO: Members, Subcommittee on Space
FROM: Majority Staff, Committee on Science, Space, and Technology
SUBJECT: Subcommittee Hearing: "Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts"
DATE: June 10, 2016

On Wednesday, June 15, 2016 at 2:00 p.m. in Room 2318 of the Rayburn House Office Building, the Subcommittee on Space will hold a hearing titled, "Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts."

Hearing Purpose

The hearing will evaluate the impacts of long duration human spaceflight on astronaut health; federal obligations and ethical considerations related to those impacts; as well as potential options for monitoring, diagnosing, and treating retired and management NASA astronauts for conditions resulting from their federal service.

Witnesses

- **The Honorable Thomas Perez**, Secretary, Department of Labor (or his designee – invited)
- **Dr. Richard Williams**, Chief Health and Medical Officer, NASA
- **Captain Chris Cassidy**, United States Navy (USN); Chief, Astronaut Office, NASA
- **Captain Scott Kelly** (USN, Ret.), Former Astronaut, NASA
- **Captain Michael Lopez-Alegria** (USN, Ret), President, Association of Space Explorers-USA; Former Astronaut, NASA
- **Dr. Jeffrey Kahn**, Professor of Bioethics and Public Policy, Johns Hopkins Berman Institute of Bioethics; Chairman, Committee on the Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights, Board on Health Sciences Policy, National Academies of Sciences

Staff Contact

For questions related to the hearing, please contact Mr. Tom Hammond, Staff Director, Space Subcommittee, at 202-225-6371.

Chairman BABIN. The Subcommittee on Space will now come to order.

Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time.

Good morning. Welcome to today's hearing titled "Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts."

I recognize myself for five minutes and an opening statement.

As a Nation, we have obligations to those we put in harm's way. As a Congress, we have a responsibility to provide for the treatment of conditions caused by federal service. As a legislator that represents the Johnson Space Center and the Astronaut Corps, I have a duty to care for my constituents.

Since the 1960s, the United States of America has asked its bravest to travel in space in service to their country. The government recognizes its obligation to care for those it puts in harm's way in other instances. For example, we provide for the care of our veterans and our federal employees when their injuries are caused by their federal service.

NASA currently provides treatment for active NASA Astronauts, and management and former astronauts are eligible for treatment of injuries sustained in their service through existing programs at the Department of Labor and the Department of Veterans Affairs.

Over the last 15 years, several reports have highlighted the potential hazards of human spaceflight and the ethical obligations that we have as a Nation, and the additional steps that we might take and need to take to address gaps in meeting those obligations.

From the dynamic launch environment to the unforgiving vacuum of space, to the energetic reentry to Earth, human spaceflight has always placed astronauts in challenging environments. Even training for spaceflight carries significant risks.

Up until recently, however, space travel was measured in days. Mercury, Gemini, Apollo, and the Space Shuttle program placed astronauts in space for relatively short periods of time. Now, with the completion of the International Space Station, our astronauts now spend months in space. The risks and potential impacts on our astronauts' health are not always seen immediately.

Captain Scott Kelly recently returned from the ISS after spending 340 days in space on one mission. This put his cumulative time in space at 520 days. Extended missions like his are teaching us a lot about the long-term effects of human spaceflight.

Weightlessness leads to osteoporosis and loss in bone density. Long-duration space missions also seem to impact vision, as 60 percent of ISS astronauts reported worsening eyesight. Furthermore, radiation exposure increases the likelihood of cancer. These are just some of the conditions we know about. Staying in space longer and pushing farther into deep space will likely present additional risks.

And while NASA attempts to mitigate these risks with protocols and countermeasures such as exercise, drug treatments, and spacecraft shielding, there will probably always be a cost to our astronauts that they bear for traveling in space.

This raises several fundamental questions. For instance, is the request for additional authority simply about treating former astronauts, or is it also about NASA getting better data on human

spaceflight? Are these two issues related? Are there classes of astronauts such as payload specialists who were not government employees that aren't covered by existing authorities? How should NASA administer treatment? Should they do it in-house or simply reimburse patients for this treatment? If NASA decided to diagnose conditions in-house, does this pose a potential conflict of interest when NASA is financially obligated to compensate former astronauts for conditions caused by their federal service? How would additional authority affect existing rights and benefits under current statutes? How would creating a new program at NASA impact the causation standard set forth by the Departments of Labor and Veterans Affairs? In other words, will a new authority make it easier or harder for astronauts to receive treatment and compensation?

In order to address these questions, Congress included a provision in the 2005 NASA Authorization Act that asked for a plan on how to best provide for former astronaut care. Similarly, the most recent Authorization Act that received unanimous support in the House and awaits consideration by the Senate contained a provision asking for a cost estimate for expanding treatment.

I think everyone here wants to make sure that we are doing right by our astronauts. They put themselves in harm's way to advance our knowledge of the universe and by bringing great pride to our Nation.

I'm also very proud to say that I represent a great number of these astronauts who call Houston their home. As a health care professional myself and as their representative, you could say it's my duty emphatically to make sure these folks are taken care of properly.

But this isn't simply about addressing a moral and ethical obligation. There is also a great benefit that we receive from providing this care. The long-term health information gained by providing treatment to former astronauts will give us a greater understanding of radiation exposure, vision impairment, bone loss, and many other ailments. This in turn will assist us to develop better monitoring and treatment protocols here on Earth for everyone, not just astronauts.

I thank today's witnesses for joining us as we discuss these very, very significant and important issues, and I look forward to hearing your testimony and your answers to our questions.

[The prepared statement of Chairman Babin follows:]



COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
June 15, 2016

Media Contacts: Alicia Criscuolo, Thea McDonald
(202) 225-6371

Statement of Chairman Brian Babin (R-Texas)

Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts

Chairman Babin: As a nation we have obligations to those we put in harm's way. As a Congress, we have a responsibility to provide for the treatment of conditions caused by federal service. As a legislator that represents the Johnson Space Center and the Astronaut Corps, I have a duty to care for my constituents.

Since the 1960's, the United States of America has asked its bravest to travel to space in service to their country. The government recognizes its obligation to care for those it puts in harm's way in other instances. For example, we provide for the care of our veterans and our federal employees when injuries result from their service.

NASA currently provides treatment for active NASA Astronauts and former astronauts are eligible for treatment for injuries sustained in their service through existing programs at the Department of Labor and the Department of Veterans Affairs. Over the last 15 years, several reports have highlighted the potential hazards of human spaceflight, the ethical obligations that we have as a nation, and additional steps that we might need to take to address gaps in meeting those obligations.

From the dynamic launch environment, to the unforgiving vacuum of space, to the energetic reentry to earth, human spaceflight has always placed astronauts in challenging environments. Even training for spaceflight carries significant risks. Up until recently, however, space travel was measured in days. Mercury, Gemini, Apollo, and the Space Shuttle program placed astronauts in space for relatively short periods of time. Now, with the completion of the International Space Station, our astronauts spend months in space and the risks and potential impacts on astronaut health are not always known immediately.

Captain Scott Kelly recently returned from the ISS after spending 340 days in space on one mission, putting his cumulative time in space at 520 days. Extended missions like his are teaching us a great deal about the long-term effects of human spaceflight. Weightlessness leads to osteoporosis and loss in bone density. Long-duration space missions seem to impact vision, as 60 percent of ISS astronauts reported worsening eyesight. Radiation exposure increases the likelihood of cancer. These are just some of the conditions we know about. Staying in space longer and pushing farther into deep space will inevitably present additional and perhaps unknown risks. While NASA

attempts to mitigate these risks with protocols and countermeasures such as exercise, drug treatments, and spacecraft shielding, there will probably always be a "health cost" our astronauts assume resulting from space travel.

These concerns raise several fundamental questions. For instance, is additional authority necessary to treat former astronauts, or is it also about NASA getting better data on human spaceflight? Are those two issues related? Are there classes of astronauts such as payload specialists who were not government employees that aren't covered by existing authorities? How should NASA administer treatment? Should they do it "in-house" or simply reimburse patients for treatment? If NASA decided to diagnose conditions "in-house", does this pose a potential conflict of interest when NASA is financially obligated to compensate former astronauts for conditions caused by their federal service? How would additional authority affect existing rights and benefits under current statutes? How would creating a new program at NASA impact the causation standard set forth by the Departments of Labor and Veterans Affairs? In other words, will a new authority make it easier or harder for astronauts to receive treatment and compensation?

In order to address these questions, Congress included a provision in the 2005 NASA Authorization Act that asked for a plan on how to best provide care for former astronauts. Similarly, the most recent Authorization Act that received unanimous support in the House and awaits consideration by the Senate contained a provision asking for a cost estimate for expanding treatment.

I believe everyone here wants to make sure we are doing the right things for our astronauts. They put themselves in harm's way to advance our knowledge of the universe and they bring great pride to our nation. I am proud to say that I represent a great number of these astronauts who call the Houston area home. As a health care professional and as their representative, you could say it is my duty to make sure these folks are taken care of properly.

But this isn't simply about addressing a moral and ethical obligation, we receive significant and on-going benefits by providing this care. The long-term health information gained from the treatment of former astronauts will give us a greater understanding of radiation exposure, vision impairment, bone-loss, and many other ailments. This in turn will assist us in developing better monitoring and treatment protocols here on earth for everyone, not just astronauts.

I thank today's witnesses for joining us as we discuss these important issues and I look forward to hearing your testimony.

###

Chairman BABIN. I now recognize the Ranking Member, the gentlewoman from Maryland, for an opening statement.

Ms. EDWARDS. Good afternoon, and thank you, Mr. Chairman. I want to extend a welcome to our distinguished panel this afternoon, and thank you as well for your patience.

Human space flight is inherently risky. That's why NASA exercises diligence and caution during all phases of a space mission, including training, vehicle flight testing, launch, mission operations, and landing.

In addition to mission risks, astronauts bear significant personal risks, particularly as they relate to their health. Health risks during long-duration flights include both short-term health consequences as well as potential long-term health conditions that may arise months and sometimes years after an astronaut's service.

This is a problem. Because of the small number of U.S. astronauts who have flown in space, and the corresponding small data set currently available on astronaut exposure during long-duration flights, characterizing those risks is a major challenge for NASA. However, if we are to go to Mars, as I have strongly advocated, mitigating these health risks is critical. But we also need to ensure that the risks NASA's astronauts take are recognized and addressed by the American people.

While active astronauts receive comprehensive health care, former astronauts do not. This needs to change. We need to ensure that care is provided for all of our NASA astronauts, not just those who are on active status. Providing ongoing medical care for active and former astronauts will give NASA the needed insight to enable earlier detection and treatment of any potential medical problems that could result from human spaceflight. It will also provide NASA with the data that are necessary to help mitigate against health risks related to future human space exploration.

This is also a recommendation of a 2014 National Academies report, which concluded that lifetime healthcare for astronauts is our ethical responsibility. The report's principle of fidelity recognizes that "Given the risks that astronauts accept in participating in hazardous missions, NASA should respect the mutuality of obligations and ensure health care and protection for astronauts not only during the mission but after return, including provision of lifetime care for astronauts."

NASA responded to the National Academies report by proposing a legislative change that would give NASA the authority to provide medical monitoring, diagnosis and treatment for psychological and medical conditions that are deemed by NASA to be associated with human spaceflight.

It's worth noting that, as the Chairman indicated, the bipartisan NASA Authorization Act of 2015, H.R. 810, that was passed by the House in February 2015, directs NASA to provide a formal response to the National Academies report. This response, as directed in the legislation, must include the budgetary resources required for implementation of the report's recommendations, as well as any options that might be considered as part of the response. Had that bill been enacted, it is likely that our discussion today would have been much better informed.

That said, Mr. Chairman, it's clear to me that ensuring comprehensive care of our astronauts before, during, and after their active service is a high priority. NASA's legislative proposal provides one option for addressing this issue, and I hope that we can explore other options as well.

However, the impact each option would have on existing authorities warrants careful consideration. For example, should Congress direct NASA to provide astronauts with lifetime healthcare in return for their service to the nation? Under this scenario, how would existing astronaut healthcare support systems be affected, including those provided by the Veterans Administration for former military astronauts? Or should Congress pattern astronaut care after NASA's legislative proposal by directing NASA to provide enhanced medical screening that would facilitate claims made by former astronauts for occupational health conditions under the FECA and VA processes and provide proactive diagnosis and treatment, if needed, while those FECA and VA processes are underway? In either scenario, how would such authority be implemented?

In addition, we need to clarify on how NASA intends to establish the causality link between human spaceflight and any identified psychological and medical conditions astronauts may develop. The bottom line here is that we need to do the right thing.

And so Mr. Chairman, if the Committee intends to address the issues contained in NASA's proposal, I would hope that we could craft legislation on a bipartisan basis, and I look forward to working with you.

Thank you, and with that, I yield the balance of my time.

[The prepared statement of Ms. Edwards follows:]

OPENING STATEMENT

**Ranking Member Donna F. Edwards (D-MD)
of the Subcommittee on Space**

House Committee on Science, Space, and Technology
Subcommittee on Space
*"Human Spaceflight Ethics and Obligations:
Options for Monitoring, Diagnosing, and Treating Former Astronauts"*
June 15, 2016

Good afternoon, and welcome to our distinguished panel of witnesses. I want to thank Chairman Babin for calling this hearing.

Human space flight is inherently risky. That is why NASA exercises diligence and caution during all phases of a space mission, including training, vehicle flight testing, launch, mission operations, and landing. In addition to mission risks, astronauts bear significant personal risks, particularly as they relate to their health.

Health risks during long duration flights include both short-term health consequences as well as potential long-term health conditions that may arise months and sometimes years after an astronaut's service. This is a problem. Because of the small number of U.S. astronauts who have flown in space, and the corresponding small data set currently available on astronaut exposure to long duration flights, characterizing those risks is a major challenge for NASA. However, if we are to go to Mars, as I have strongly advocated, mitigating these health risks is critical. But we also need to ensure that the risks NASA's astronauts take are recognized and addressed by the American people.

While active astronauts receive comprehensive health care, former astronauts do not. This needs to change. We need to ensure that care is provided for all of our NASA astronauts, not just those who are on active status.

Providing ongoing medical care for active and former astronauts will give NASA the needed insight to enable earlier detection and treatment of any potential medical problems that could result from human spaceflight. It will also provide NASA with the data that are needed to help mitigate against health risks related to future human space exploration.

This is also the recommendation of a 2014 National Academies report, which concluded that lifetime healthcare for astronauts is our ethical responsibility. The report's principle of "Fidelity" recognizes that *"Given the risks that astronauts accept in participating in hazardous missions, NASA should respect the mutuality of obligations and ensure health care and protection for astronauts not only during the mission but after return, including provision of lifetime care for astronauts"*.

NASA responded to the National Academies report by proposing a legislative change that would give NASA the authority to provide medical monitoring, diagnosis and treatment for

psychological and medical conditions that are deemed by NASA to be associated with human spaceflight.

It is worth noting that the bi-partisan NASA Authorization Act of 2015, H.R. 810, passed by the House in February 2015, directs NASA to provide a formal response to the National Academies report. This response must include the budgetary resources required for implementation of the report's recommendations, as well as any options that might be considered as part of the response. Had the bill been enacted, it is likely that our discussion today would have been better informed.

That said Mr. Chairman, it is clear to me that ensuring comprehensive care of our astronauts before, during, and after their active service is a high priority. NASA's legislative proposal provides one option for addressing this issue, and I hope that we can explore other options as well.

However, the impact each option would have on existing authorities warrants careful consideration. For example: *Should Congress direct NASA to provide astronauts with lifetime healthcare in return for their service to the Nation? Under this scenario, how would existing astronaut health care support systems be affected, including those provided by the Veterans Administration (VA) for former military astronauts?*

Or should Congress pattern astronaut care after NASA's Legislative Proposal by directing NASA to provide enhanced medical screening that would (a) facilitate claims made by former astronauts for occupational health conditions under the FECA and VA processes and (b) provide proactive diagnosis and treatment, if needed, while those FECA and VA processes are underway?

In either scenario, how would such authority be implemented?

In addition, we need clarity on how NASA intends to establish the causality link between human spaceflight and any identified psychological and medical conditions astronauts may develop. But the bottom line is that we need to do the right thing.

Mr. Chairman, if the Committee intends to address the issues contained in NASA's proposal, I would hope that we could craft legislation on a bipartisan basis, and I look forward to working with you.

Thank you and I yield back the balance of my time.

Chairman BABIN. Thank you very much, Ms. Edwards.

I now recognize the Chairman of our full Committee, Mr. Smith from Texas.

Chairman SMITH. Thank you, Mr. Chairman, and welcome to our all of our witnesses today including three astronauts. I often say publicly, and I'll say again now, that I consider astronauts to be our modern heroes for many, many reasons, and certainly appreciate their presence here today.

Mr. Chairman, I also believe this is probably the first hearing we have had dedicated entirely to the subject of astronauts' health in space, and so it's most timely, and as you and the Ranking Member both mentioned, it might lead to legislation that can be helpful to them in the future.

Since NASA selected the first group of astronauts in 1959, more than 300 of America's finest have ventured into the cosmos as explorers. Each one of these astronauts represented the compelling urge of humankind to explore and to discover and the lure of curiosity that leads us to try to go where no one has gone before. From Neil Armstrong's first step on the Moon to Captain Kelly's one-year voyage on the International Space Station, their peaceful exploration of outer space continues to inspire our nation and the world.

In an age when spaceflight has come to seem almost routine, it is easy to overlook how dangerous it is and how little we know about the long-term health effects of spaceflight.

For almost 20 years, astronauts have lived on the International Space Station. One of their primary missions has been to learn about the physiological and psychological effects of long-duration human spaceflight. Captain Kelly's one-year mission was in pursuit of a scientific understanding of how the human body responds to extended space flight.

But even with our 20 years of experience on the ISS, we are only just beginning to understand the effects of long-duration missions. Our lack of knowledge becomes especially evident as NASA prepares for its journey to Mars.

Only 24 individuals have journeyed beyond low-earth orbit. All of these astronauts flew during the Apollo era and never for more than a handful of days. Using our current propulsion technology, a successful mission to Mars will require astronauts to survive a roundtrip spaceflight of no less than several hundred days, and unlike our near-Earth environment, the trip to Mars will offer no natural protection from galactic cosmic rays and solar radiation.

Today, through its Lifetime Surveillance of Astronaut Health program, NASA screens and monitors astronauts for occupational related injury or disease. This program contributes to our scientific knowledge of long-term health effects and assists participating astronauts in monitoring for spaceflight related illnesses and disease.

But this program does not provide for diagnosis or treatment of those no longer serving, nor for management and retired astronauts because NASA is not explicitly authorized to provide such services. These astronauts can receive treatment from the Department of Labor or the Veterans Administration now, but this may not be the best process for the former astronauts or NASA's developing knowledge base.

We as a nation have a responsibility to ensure that our astronauts, both active and retired, are provided with appropriate monitoring, diagnosis, and treatment of spaceflight-related injuries and disease. This is also the recommendation of the National Academy of Sciences in its review of NASA's study of astronaut health.

For our nation, the question should not be whether we should provide these services to our astronauts, but rather how to do it in a way that best addresses the current and future needs of our space explorers in America's quest for discovery of new frontiers.

Thank you Mr. Chairman, and I'll yield back.

[The prepared statement of Chairman Smith follows:]



COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY
Lamar Smith, Chairman

For Immediate Release
June 15, 2016

Media Contacts: Alicia Criscuolo, Thea McDonald
(202) 225-6371

Statement of Chairman Lamar Smith (R-Texas)

Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts

Chairman Smith: Thank you, Mr. Chairman, and welcome to our witnesses. Captain Cassidy, Captain Kelly, and Captain Lopez-Alegria.

Since the National Aeronautics and Space Administration (NASA) selected the first group of astronauts in 1959, more than three hundred of America's finest have ventured into the cosmos as explorers. Each one of these astronauts represented the compelling urge of humankind to explore and to discover. And the lure of curiosity that leads one to try to go where no one has gone before.

From Neil Armstrong's first step on the Moon to Captain Kelly's one-year voyage on the International Space Station, their peaceful exploration of outer space continues to inspire our nation and the world.

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But even with our twenty years of experience on the ISS, we are only just beginning to understand the effects of long-duration missions.

Our lack of knowledge becomes especially evident as NASA prepares for its journey to Mars. Only twenty-four individuals have journeyed beyond low-earth orbit. All of these astronauts flew during the Apollo era and never for more than a handful of days.

Using our current propulsion technology, a successful mission to Mars will require astronauts to survive a roundtrip spaceflight of no less than several hundred days. And unlike our near-Earth environment, the trip to Mars will offer no natural protection from galactic cosmic rays and solar radiation.

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We, as a nation, have a responsibility to ensure that our astronauts, both active and retired, are provided with appropriate monitoring, diagnosis, and treatment of spaceflight related injuries and disease. This is also the recommendation of the National Academy of Sciences in its 2004 review of NASA's longitudinal study of astronaut health.

For our nation, the question should not be whether we should provide these services to our astronauts, but rather how to do it in a way that best addresses the current and future needs of our space explorers in America's quest for discovery of new frontiers. Thank you Mr. Chairman, I yield back.

###

Chairman BABIN. Thank you, Mr. Chairman. I appreciate you.

I now recognize the Ranking Member of the full Committee for a statement, Ms. Johnson from Texas.

Ms. JOHNSON. Thank you very much, and good afternoon. Let me welcome our distinguished witnesses.

Mr. Chairman, I'd like to thank you for holding this hearing on "Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts."

Our NASA astronauts are American heroes, and they are some of the most accomplished, highly trained, and courageous individuals who serve our nation in the pursuit of furthering our exploration of outer space.

Astronauts and our human space program also inspire the next generation, with many of our youngest Americans dreaming of one day following in their footsteps and exploring outer space. And I might add that no child falls asleep when there's an astronaut speaking in high schools.

It is no surprise that our astronauts are held in very, very high regard. They accept considerable risks in doing their jobs and serving our nation. And over the decades that we have been sending humans into outer space, more than a dozen NASA astronauts have paid the ultimate price as part of this service.

That's why I'm pleased that we are examining the responsibility we have to care for our astronauts, even after they have left active status including looking at the risk of cancer, musculoskeletal conditions, and ocular disorders are just a few of the known health concerns related to human spaceflight. But there is still much that we are learning and need to learn about the potential effects of space on the human body and on human health.

Congress has acted to ensure that others we have put in harm's way, such as those who have served in our military, receive lifetime healthcare. It is time we do the same for NASA astronauts.

The practicalities of how we authorize the provision of such health care is very important, and I look forward to hearing from our witnesses on key questions and issues that Congress needs to consider before we legislate in this area.

I thank you, Mr. Chairman, and yield back.

[The prepared statement of Ms. Johnson follows:]

OPENING STATEMENT

Ranking Member Eddie Bernice Johnson (D-TX)

House Committee on Science, Space, and Technology
Subcommittee on Space

*“Human Spaceflight Ethics and Obligations:
Options for Monitoring, Diagnosing, and Treating Former Astronauts”*
June 15, 2016

Good afternoon, and welcome to our distinguished panel of witnesses. I want to thank you, Mr. Chairman, for holding this hearing on *“Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and Treating Former Astronauts”*.

Our NASA astronauts are American heroes. They are some of the most accomplished, highly trained, and courageous individuals who serve our nation in the pursuit of furthering our exploration of outer space.

Astronauts and our human space program also inspire the next generation, with many of our youngest Americans dreaming of one day following in their footsteps and exploring outer space. It is no surprise that our astronauts are held in such high regard.

They accept considerable risks in doing their jobs and serving our nation. And over the decades that we have been sending humans into outer space, more than a dozen NASA astronauts have paid the ultimate price as part of this service. That is why I'm pleased that we are examining the responsibility we have to care for our astronauts, even after they have left active status.

Increased risk of cancer, musculoskeletal conditions, and ocular disorders are just a few of the known health concerns related to human spaceflight. But there is still much that we are learning and need to learn about the potential effects of space on the human body and on human health. Congress has acted to ensure that others we have put in harm's way, such as those who have served in the military, receive lifetime healthcare. It is time we do the same for NASA astronauts.

The practicalities of how we authorize the provision of such health care are important, and I look forward to hearing from our witnesses on key questions and issues that Congress needs to consider before we legislate in this area.

Thank you, Mr. Chairman, and I yield back.

Chairman BABIN. Yes, ma'am. Thank you.

Now I'd like to introduce our panel of distinguished witnesses.

Our first witness today is Dr. Richard Williams, Chief Health and Medical Officer for NASA. In this role, Dr. Williams is responsible for the oversight of all health and medical activities at NASA including the medical aspects of all national and international NASA missions involving humans. He has extensive experience in the clinical practice of general surgery, aerospace medicine, and occupational medicine as well as in administrative medical management. During his 27-year Air Force career, Dr. Williams served in a wide variety of settings as a clinical practitioner and medical leader including service in the contingency deployments. Dr. Williams holds an M.D. degree from the Virginia Commonwealth University and completed residencies in general surgery at Wright State University and an aerospace medicine and occupational medicine at the United States Air Force School of Aerospace Medicine at Brooks Air Force Base in Texas. Thank you for being here.

Second witness today Captain Chris Cassidy, a United States Navy SEAL and the 16th Chief of the Astronaut Office at NASA. As NASA's Chief Astronaut, he is responsible for flight assignments, mission preparation, and on-orbit support of U.S. crews as well as organizing astronaut office support for future launch vehicles. Captain Cassidy was selected as an astronaut by NASA in 2004, and he's a veteran of two space flights, STS-127 and Expedition 35. During STS-127, Cassidy served as a Mission Specialist and was the 500th person in history to fly into space. Captain Cassidy has been deployed twice to the Mediterranean and twice to Afghanistan. He is the recipient of the Bronze Star with a Combat V and Presidential Unit Citation for leading a nine-day operation at the Zawar Kili Cave on the Afghanistan-Pakistani border. Captain Cassidy received a bachelor of science in mathematics from the U.S. Naval Academy and a master of science in ocean engineering from Massachusetts Institute of Technology. Thank for being here. I'm the proud father of a Navy SEAL myself.

Our third witness today is Captain Scott Kelly, a retired U.S. Naval Officer and former NASA Astronaut, who is fresh off his one-year mission in space. Welcome home, Captain Kelly. I've had the distinct pleasure and honor of meeting and visiting with Captain Kelly on several occasions before and after his historic mission. In 1996, Captain Kelly was selected by NASA. He has logged more than 520 days in space on four space flights and served as Space Shuttle Pilot on STS-103 in 1999 and was the Mission Commander on STS-118 in 2007. Captain Kelly also served as a Flight Engineer for ISS Expedition 25, and as the Commander of ISS Expedition 26. In March of 2015, Captain Kelly launched for a one-year mission to the ISS serving as a Flight Engineer for Increments 43 and 44 and Commander for Increments 45 and 56. Captain Kelly returned to Earth on March 2nd, 2016, after his historic 340-day mission aboard the ISS. Captain Kelly received a bachelor of science degree in electrical engineering from the State University of New York Maritime College and a master of science degree in aviation systems from the University of Tennessee in Knoxville. Thanks for being here, Captain Kelly.

Our fourth witness today is Captain Michael Lopez-Alegria, President of the Association of Space Explorers-USA, a retired U.S. Naval Officer, and former NASA Astronaut. Captain Lopez-Alegria has over 35 years of aviation and space experience with the U.S. Navy and NASA and a variety of roles including Naval Aviator, Engineering Test Pilot, and Program Manager, NASA Astronaut, and International Space Station Commander. He is a four-time astronaut, having flown on Space Shuttle Missions STS-73, STS-92, and STS-113, and serving as Commander of ISS Expedition 14, flying to and from the ISS aboard Soyuz-IMA-9. He holds NASA records for the most extravehicular activities, or spacewalks, or EVAs, 10 EVAs and cumulative EVA time of 67 hours and 40 minutes. Captain Lopez-Alegria received a bachelor of science in systems engineering from the U.S. Naval Academy and master of science in aeronautical engineering from the U.S. Naval Postgraduate School. He is also a graduate of Harvard University's Kennedy School of Government Program for Senior Executives and National and International Security. Thank you for being here today, Captain.

Our final witness today Dr. Jeffrey Kahn, Professor of Bioethics and Public Policy at Johns Hopkins Berman Institute of Bioethics, and Chairman of the Committee on Ethics, Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights for the Board on Health Sciences Policy at the National Academies of Sciences. His research interests include the ethics of research, ethics in public health, and ethics in emerging biomedical technologies. Dr. Kahn speaks widely both in the United States and abroad and has published four books and over 125 articles in bioethics and medical literature. Dr. Kahn received his B.A. from the University of California-Los Angeles, Ph.D. from Georgetown University, and MPH from Johns Hopkins Bloomberg School of Public Health.

The Committee also invited a representative from the Department of Labor to discuss how the Department of Labor currently provides for treatment of federal employees under the Federal Employee Claims Act, or FECA. The Committee sent Secretary Perez or anyone in the agency that he would like to designate an invitation to appear. Unfortunately, the Department of Labor could not find anyone to appear, which is very surprising since there are 17,000 employees at the Department of Labor.

Furthermore, we only asked them to comment on what they already do. Executive Branch officials have a responsibility to Congress and to the taxpayers of the United States to provide testimony and inform the legislative process. I am disappointed that a federal agency was unable to assist Congress, failing to fulfill this fundamental responsibility. It is no wonder that NASA wants to handle these issues themselves.

I would now like to recognize Dr. Williams for five minutes to present his testimony.

**TESTIMONY OF DR. RICHARD WILLIAMS,
CHIEF HEALTH AND MEDICAL OFFICER, NASA**

Dr. WILLIAMS. Mr. Chairman and Members of the Committee, thank you for this opportunity to appear before you today to dis-

cuss the critical issue of astronaut healthcare. This is an issue that has consumed me in my role as Chief Health and Medical Officer for NASA, and I am very grateful that the Committee is using its limited time and resources to focus on this critical agency priority.

Astronauts are exposed to unique hazards that no one else on Earth has experienced. Microgravity and space radiation are just two of the exposures that are only found when we venture into space. Some conditions such as reduced muscle mass caused by exposure to microgravity are somewhat foreseeable while others are complete surprises. Certainly, the visual problems and increased risk of cataracts astronauts experience was not expected or predicted.

For active astronauts, NASA currently provides medical care and treatment. We also use data from the treatment of active astronauts to figure out ways to minimize negative impacts to astronaut health.

Some of the things we do include monitoring for radiation exposure, using exercise to combat microgravity effects, and continued health monitoring. While these efforts can't entirely mitigate exposure to space, they are valuable.

However, when it comes to former astronauts, the situation is different. We invite astronauts to participate in our voluntary Lifetime Surveillance of Astronaut Health program. This includes a limited health status evaluation on an annual basis at the Johnson Space Center Flight Medical Clinic.

However, if there are questions or concerns from this evaluation, NASA can only encourage astronauts to follow up with their personal healthcare providers. This presents a number of problems. NASA cannot do all the tests it believes need to be done to effectively monitor former astronauts as some of these tests would be considered personal healthcare. If personal physicians do tests and evaluations, we often do not have access to the data unless the astronaut aggressively pursues getting this data to us. And healthcare providers often don't understand the need for some of the targeted tests that we require for occupational health surveillance and would not routinely order them.

For example, some astronauts should probably be receiving yearly MRI scans of the area around their eyes. MRI scans are not normally used as preventive screening; they are usually ordered in response to illness or injury.

I need to emphasize how small this population is. There are only 280 living astronauts that have flown in space—280. That isn't even enough to take a good consumer product survey, let alone try to predict what effects human spaceflight might have on the human body 10, 20 or 30 years down the road. An average doctor or nurse practitioner no matter how skilled they are has no exposure to or understanding of these issues.

With only 280 people to collect data from, we need to get as much data as possible from every one of them. With only 60 percent of our former astronauts participating in the current surveillance program, expanding our authority to provide for extensive testing would be a great incentive to increase this number. We believe 80 percent or more would participate if our authority to provide testing and monitoring was expanded.

Being able to gather data on astronauts' medical conditions and understand the health impact of spaceflight exposures over time is essential to provide crew health and safety during long-term journeys beyond low-Earth orbit. If we're serious about going anywhere beyond low-Earth orbit, we'll need to understand these risks.

Ethically, we will make sure all decisions astronauts make about their healthcare and personal information are completely voluntary. This brings me to an issue that may even be more important than our need for data, and that is our ethical obligation to our astronauts. When the United States government puts individuals in harm's way, our government has an obligation to care for them. Our military personnel are provided the care they need for the hazards and dangers they have faced in service to our country. The Institute of Medicine has in multiple studies pointed out that NASA has an ethical obligation to the astronauts who have dared exposures no other human beings in history has faced.

To meet the health needs of our astronauts and to live up to our ethical obligations, I urge Congress to act to ensure we can safeguard the well-being of our former and future astronauts.

Mr. Chairman, I would be glad to answer any question you or any other member might have.

[The prepared statement of Dr. Williams follows:]

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UNTIL PRESENTED
BY WITNESS
June 15, 2016

**Statement of
Dr. Richard Williams M.D.
Chief Health and Medical Officer
National Aeronautics and Space Administration**

before the

**Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss NASA's current efforts in astronaut occupational health and a legislative proposal we have presented to Congress that would allow the Agency to perform annual medical monitoring and provide diagnosis and treatment for active as well as former astronauts throughout their lifetime for medical conditions which are deemed to be associated with human spaceflight. Provision of these services will help NASA gather long-term health data that will lower the risk for future space travelers.

Background

Like many industrial and military occupational settings, human spaceflight is associated with occupational environmental exposures, some of which are documented to be harmful to human health and performance. Unlike those fairly well-characterized terrestrial work environments, the spaceflight environment includes hazards/stressors that are unique and whose effects on humans are not well understood, due largely to the limited data set generated during the relatively short time that humans have been flying extended missions in space. During spaceflight missions, astronauts are subjected to hazards that include radiation and microgravity exposure, isolation, and confinement in the closed environment of spacecraft that cause astronauts to experience chronic long-term exposure to elevated carbon dioxide (10-20 times above Earth normal) and low levels of known toxins. These hazards and subsequent exposures drive human health risks for NASA astronauts.

NASA has implemented a systematic approach that gathers evidence to assess and mitigate these risks for both in-mission health and long-term health. NASA's Office of the Chief Health and Medical Officer generates Health Standards to provide requirements for NASA's development and operational programs to mitigate these risks, but these health risks cannot be eliminated entirely with present day knowledge/technology. More data is needed to better understand and mitigate the risks to astronauts.

Clinical findings indicate that astronauts experience increased risk of cataracts, reduced visual acuity, bone strength loss, post-mission renal stones, serious shoulder injuries, and other

orthopedic/musculoskeletal injuries, as a result of spaceflight and/or spaceflight training. Medical experts strongly believe that an association exists between human spaceflight and the increased risk of developing these and other related conditions. Scientific findings indicate that due to spaceflight radiation exposure, astronauts will have a higher incidence of cancer later in life than those not exposed. Several other conditions are believed to be associated with spaceflight, but sufficient evidence has not yet been compiled due to the relatively short history of the “occupation” and the small numbers of “subjects” to prove these associations. Prospective studies and medical research and medical monitoring programs are ongoing to further understand the effect of these exposures. As data emerge with ongoing long-duration spaceflight experience, we believe that other unsuspected medical conditions associated with spaceflight may become evident as well.

The legislation we have proposed to Congress will enhance our ability to safely conduct human spaceflight missions with future generations of space travelers as well as provide equity for the men and women who performed activities unique to United States human spaceflight achievements. It will do so by providing a process of efficient and uniform data gathering, monitoring, and treatment for medical conditions, which exist due to spaceflight.

NASA’s Current Efforts in Astronaut Data Gathering and Health Care

Active Astronauts

NASA currently provides both medical care and treatment for astronauts while they are active members of the astronaut corps. Health care includes routine occupational health and preventive examinations, and customized occupational monitoring based on individual astronaut exposures. The program also involves the ongoing and systematic collection, analysis, and interpretation of physiologic and exposure data to identify, mitigate, and control health risks to the astronaut.

NASA employs many strategies to minimize the impact to astronaut health, and ensures that any astronaut health and performance issues are considered and raised to the highest levels of NASA management when appropriate. These strategies include: standards to select the healthiest individuals, annual health monitoring to ensure fitness, proactive training programs and state of the art training facilities, flight assigned medical standards, and unique mission requirements to help mitigate the human risks for spaceflight. However, these efforts cannot entirely mitigate the hazards of spaceflight that astronauts are exposed to.

Former Astronauts

In the “Lifetime Surveillance of Astronaut Health” (LSAH) Program, former astronauts are invited to voluntarily participate in a surveillance program of astronaut health, which includes limited health status evaluations on an annual basis at the Johnson Space Center Medical Clinic. When these evaluations uncover medical findings or raise questions, NASA is only authorized to encourage the former astronaut to follow up with their personal health care providers.

NASA utilizes the medical data from these surveillance evaluations to further understand the effects of spaceflight on long-term health of the astronauts. This is the core evidence that is

utilized by NASA for understanding the risks of spaceflight and for generating health standards and risk mitigations. Presently, approximately 60% of former astronauts participate in the surveillance program. Given the limited supply of subjects (there are approximately 250 living former astronauts), increasing the rate of participation is important to enable NASA to obtain more health care data/evidence. If the legislation is enacted, the Agency would be able to expand the scope of diagnostic care for former astronauts to include preventive medical exams for early detection and management of occupational disease. It is estimated with this expanded care NASA can increase participation to at least 80%.

External Reviews

The Institute of Medicine (IOM), part of the National Academies of Sciences, Engineering, and Medicine, has reviewed NASA's astronaut health care numerous times over the past two decades. At each review, the IOM has consistently emphasized the need for NASA to adopt a comprehensive health care program for all its astronauts. In 2001, the Institute of Medicine released a report entitled "Safe Passage: Astronaut Care for Exploration Missions," in which it recommended that "NASA should develop a comprehensive health care system for astronauts for the purpose of collecting and analyzing data while providing the full continuum of health care to ensure astronaut health." In 2004, the Institute of Medicine released another report entitled "A Review of NASA's Longitudinal Study of Astronaut Health." In this publication, the IOM recommended that NASA convert to an Occupational Surveillance program in addition to their research program, and specifically cited the Department of Energy (DOE), Department of Veteran's Affairs, and Department of Defense as examples of successful government occupational surveillance programs. Specific input from the IOM reviews include:

- *"...the committee believes that the National Aeronautics and Space Administration (NASA) should have a policy addressing the practical consequences of discovering that a career as an astronaut, or the experience of space travel, leaves astronauts at increased risk for an adverse health effect.*
- *Of particular concern is the case in which the effect, ... does not become obvious during or immediately after a space flight but instead develops sometime after the astronaut leaves active duty and is no longer provided medical care by NASA.*
- *What is NASA's ethical responsibility in this circumstance? It seems evident that the federal government should take full responsibility for health care needs in the case of a disease or disorder unique to space travel or the training required for space travel."*

The Institute of Medicine's most recent report (2014) entitled "Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework" states that NASA has an ethical and moral imperative to ensure access to health care, longitudinal follow up, and preventive long-term health screening of current and former astronauts.

Proposed Legislative Content

The new legislation would provide the NASA Administrator authority to allow the Agency to expand annual medical monitoring and provide diagnosis and treatment for former crew members throughout their lifetime for medical conditions which are deemed by NASA to be associated with human spaceflight.

Medical monitoring will focus on early detection of health conditions that may be related to occupational exposures incurred during spaceflight or spaceflight training. Targeted surveillance strategies could include monitoring for cancers, cataracts, visual changes associated with elevated intracranial pressure, injuries resulting from training or spaceflight, and reduced bone strength and fracture associated with loss of bone mineral. An individualized monitoring plan would also be implemented based on each astronaut's occupational exposure. Medical treatment would be provided for conditions which, as deemed by NASA, may not have occurred absent spaceflight or may have been exacerbated by spaceflight. Records of medical monitoring, diagnosis, and treatment would be provided to NASA.

Access to these records would further enable NASA to establish an evidence base to guide diagnosis and treatment for latent occupationally related conditions in a similar manner to Federal models such as the DOE's Former Worker Medical Screening Program. The expanded data acquired would be used to tailor treatments, inform the development and refinement of spaceflight health standards, inform requirements for new spaceflight medical hardware, and develop exposure controls in order to prevent disease occurrence in the astronaut corps.

Implementation

NASA has the ability to administer this new activity via the existing infrastructure within the Office of the Chief Health and Medical Officer at NASA Headquarters and the Johnson Space Center (JSC) Flight Medical Clinic. These competencies/capabilities include physicians, epidemiologists, health care competencies, and management oversight capability. NASA's existing health care management structure can easily support the review and controls necessary to implement this legislation. In the event that a former astronaut who qualifies for Federal Employees' Compensation Act (FECA) needs extended medical care or experiences disability, we will work closely with our agency partners at the Department of Labor in coordinating with the FECA program. NASA is not seeking to remove itself from the FECA program or create its own workers' compensation system.

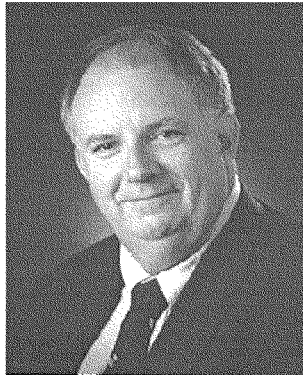
Conclusion

This new legislation would provide the Administrator authority to allow NASA to meet the moral and ethical obligations to protect our current and former astronauts by performing annual medical monitoring and providing diagnostic services and treatment for former astronauts, in addition to active ones. These services would be conducted throughout the astronauts' lifetimes for medical conditions which are deemed to be associated with human spaceflight. The comprehensive preventive screening would help minimize catastrophic issues and the additional

data acquired would enable NASA to better understand the risks of spaceflight, minimize these risks, and enable future long duration missions to Mars and beyond.

Mr. Chairman, I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

Biography of NASA's Chief Health and Medical Officer



Dr. Richard Williams serves as NASA's Chief Health and Medical Officer and is responsible for the oversight of all health and medical activities at NASA, including medical aspects of all national and international NASA missions involving humans. He holds an M.D. degree from the Virginia Commonwealth University (Medical College of Virginia), and completed residencies in General Surgery at Wright State University and in Aerospace Medicine and Occupational Medicine at the USAF School of Aerospace Medicine at Brooks AFB, Texas. A Fellow of the American College of Surgeons, he is certified by both the American Board of Surgery and the American Board of Preventive Medicine (Aerospace Medicine). He has extensive experience in the clinical practice of general surgery, aerospace medicine and occupational medicine as well as in administrative medical management. He has held appointments as Assistant Clinical Professor of Surgery at Wright State University and Associate Clinical Professor of Surgery at the Medical College of Virginia.

During his 27 year Air Force career, Dr. Williams served in a wide variety of settings as a clinical practitioner and medical leader, including service in contingency deployments. His military decorations and civilian honors include the Bronze Star Medal, the John R. Tamisea Award, the NASA Space Flight Safety Award, and the Melbourne C. Boynton Award. Dr. Williams is also a designated senior FAA Aviation Medical Examiner and an active instrument-rated private pilot with over 3500 hours flying single and multi-engine aircraft.

Chairman BABIN. Thank you, Dr. Williams.
I now recognize Captain Cassidy for five minutes to present his testimony.

**TESTIMONY OF CAPTAIN CHRIS CASSIDY,
UNITED STATES NAVY (USN);
CHIEF, ASTRONAUT OFFICE, NASA**

Captain CASSIDY. Mr. Chairman and Members of the Committee, I sincerely appreciate the chance to appear before you today. Thank you very much.

As the Chief Astronaut for NASA, this issue is not only critically important to the agency but also of great importance to myself, both professionally and personally. In my role as the Chief, I serve in the most senior leadership position for active astronauts. I am the principal adviser Administrator Bolden through NASA leadership and the chain of command on all aspects of astronaut operations. This covers a wide variety of tasks from astronaut training, operations, and safety to advising on spacecraft design and even finding astronauts to speak in order to inspire our nation's students and the public and to keep those high school students from falling asleep.

We take healthcare very, very seriously. Other than our crew, the most precious resource on the International Space Station is time. We have an international mix of six crew members on the Space Station, and each of them has only 16 hours of awake time per day. Every minute of this period is treated as a critical resource similar to that of air, water or food. This time is used to accomplish the hundreds of scientific experiments to execute the many tasks required to keep the ISS functioning yet we still schedule two hours of exercise every single day. This is done simply because it's the best way we have found to counteract the effects of microgravity exposure. Without a doubt, there are many other tasks that could be accomplished with those two hours. However, absolutely nothing is more important than keeping our astronauts as healthy as we possibly can.

Our knowledge of the kinds of health changes associated with the exposure to space has increased as more astronauts fly on the Space Station. Conditions have surfaced after long-duration spaceflight that were not apparent in short-term space exposure. For example, muscle atrophy and the associated bone loss have been experienced on longer-duration flights that were not a concern on shorter missions.

There are other major risks to long-term exposure to space. There is far more radiation in space without the protection of Earth's magnetic field. There is also experimental evidence that radiation encountered in space as compared to gamma or X-rays commonly encountered on Earth is more effective at causing the type of biological damage that ultimately leads to cancer. This means that astronauts need to be more closely monitored for cancer for the rest of their lives versus someone who has not flown in space.

Right now, NASA only has limited authority to provide medical monitoring for former astronauts. Our current program, the Lifetime Surveillance of Astronaut Health, does basic health screening but can't provide for the advanced monitoring and testing that is

needed. Expanding the tests and conditions NASA can proactively monitor would greatly assist in establishing the evidence base that we need. It would also increase the numbers of astronauts who participate. With only about 280 living people who have flown in space, and about 60 percent of those former astronauts participating in a limited health evaluation, every additional astronaut who can be part of this population is vital.

The other reason for doing this extensive monitoring is to catch medical conditions in the early stages before they become more serious. Proactive monitoring gives us a much better chance of treating diseases in the early stages with a greater likelihood for a positive outcome.

The lack of advanced monitoring worries me for another reason. We are involved in helping to evaluate our new generation of spacecraft, and the lack of data hampers us in our efforts to go beyond low-Earth orbit. How do we design vehicles to protect against the long-term effects of microgravity and radiation exposure if we still aren't certain of what those effects entirely are?

I work with our Astronaut Corps on a daily basis. This isn't just an abstract issue for me. I know these men and women and their families. Their dedication, enthusiasm, bravery and diligence while they voluntarily accept the risks and dangers of spaceflight, that should not be an excuse to not be thorough with their health. We need to do everything in our power to understand and minimize the hazards they face in order to further protect future generations of Americans who will one day live off of our planet.

Mr. Chairman, I would be happy answer your questions, and I look forward to them. Thank you.

[The prepared statement of Captain Cassidy follows:]

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UNTIL PRESENTED
BY WITNESS
June 15, 2016

**Statement of
Chris Cassidy
Captain, U.S. Navy and
Chief Astronaut of the Astronaut Office
National Aeronautics and Space Administration**

before the

**Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to appear before you and discuss the efforts of NASA's Astronaut Office to safeguard and maintain the health of NASA's astronaut corps.

The Chief of the Astronaut Office is the most senior leadership position for active astronauts in the Astronaut Corps. I serve as head of the Corps and am the principal adviser to the NASA Administrator, and the NASA chain of command, on astronaut training and operations. In this position, I am responsible for managing the resources, operations, and safety programs for the entire astronaut corps. As the 500th person to fly into space, and a veteran of two space flights (first on the Space Shuttle Endeavour (STS-127) and later on a Soyuz (TMA-8M)), I have experienced firsthand the physical and mental challenges astronauts undergo.

Our office provides spaceflight operators for a variety of spacecraft; ground support for spaceflight; evaluation, testing, and development of new vehicle designs; and support for the education and public outreach office, which coordinates astronaut appearances to speak to and inspire students and the public. The International Space Station (ISS) has had a continuous human presence for over 15 years. An international mix of six crew members is maintained on the ISS, and each of these crew members begins training two and a half years before an anticipated launch. These are six-month missions, which includes research, technology demonstrations, extra-vehicular activity, robotics, payloads, cargo, and resupply. Additionally, we also support the Mission Control Center, which handles all command and control of the ISS and communications with the onboard crew.

We work closely with the Office of the Chief Health and Medical Officer (OCHMO). As the office responsible for policy and oversight of all health and medical activities at NASA, OCHMO coordinates and supports space medicine, including ground-based analogs for space missions, the development of vehicles for human and animal access to space, ISS activities, and planning for future space missions.

While human spaceflight has always been inherently dangerous, and though astronauts accept that risk, my job, and the job of the Agency, is to understand and minimize that risk. As is the case for all NASA leadership, I am very committed to that aspect of our mission. One of the most precious resources we have on the ISS is the astronaut's time. Every minute of the 16 hours of awake crew time per day is treated as a critical resource similar to air, water, and food. This time is used to accomplish the hundreds of scientific experiments, perform corrective and preventive maintenance, load and unload supply ships, and execute many operational tasks required to keep the ISS functioning. Yet, despite these competing priorities for crew time, NASA will always allocate two hours per day to exercise. We have learned that resistive exercise is the single most effective countermeasure to the muscle mass loss and bone density loss that is caused by microgravity. NASA's willingness to commit those precious hours to safeguard the health of the crew demonstrates how seriously we take protection of the Agency's astronauts.

Our knowledge of the kinds of health challenges associated with exposure to space has increased as more astronauts fly on the ISS. Conditions have surfaced after long-duration spaceflight that are not apparent in short-term space exposure. For example, the muscle atrophy and associated loss of bone densification experienced on long-duration flights were not a concern on shorter flights. With new knowledge, we now can proactively treat this condition using daily exercise. Extended missions on the ISS enabled NASA to discover the problem and develop an effective countermeasure.

As you know, NASA has learned and continues to learn a tremendous amount from Scott Kelly's one-year mission. The Agency has also taken advantage of the fact that retired astronauts Scott and Mark Kelly are twins. While Scott spent almost a year in space, Mark stayed here on earth. The Twins Study now will look at the differences and similarities between them to go further in our understanding of the risks of exposure to spaceflight. The Twins Study was the first study of its kind to compare molecular profiles of identical twin astronauts with one in space and another on Earth. We are hopeful that the integration of scientists, research, and data in this study may lead to personalized countermeasure packages to optimize the safety and performance of individual astronauts.

I will point out that Scott and Mark Kelly are now both retired from NASA. NASA's retired astronauts are vital to our continued research into the health challenges of space exploration. Former astronauts are invited to voluntarily participate in NASA's Lifetime Surveillance of Astronaut Health. A limited health status evaluation is provided to former crew members on an annual basis at the Johnson Space Center Flight Medicine Clinic. The limited medical data collected by NASA is reviewed to inform the Agency of the potential long-term health consequences of spaceflight.

However, the inability to perform more extensive medical evaluations limits NASA's understanding of conditions that may not surface until years or even decades after exposure to

space. Expanding the tests and conditions NASA can proactively monitor would greatly assist in establishing the evidence base we need. It would also increase the numbers of astronauts who participate. With only approximately 250 former astronauts and payload specialists living, and only 60% of them participating in the limited health status evaluation, every additional astronaut who is encouraged to participate is vital.

Expanding the occupational surveillance and preventive medicine exams is critical in tailoring treatment, informing the requirements for new spaceflight medical hardware, and developing controls in order to prevent disease occurrence in the astronaut corps due to spaceflight. As NASA moves forward with commercial crew and beyond low-earth orbit mission design, part of the job of the Astronaut Office is to ensure those designs incorporate the latest information on the physical challenges of human spaceflight. All the data we can collect and every condition we can proactively monitor is important to NASA and the future of humankind off the planet Earth.

In 2014, the Institute of Medicine (IOM) released their "Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework." In this study, the IOM stated:

The agency should also provide preventive long-term health screening and surveillance and lifetime health care to protect astronaut health, support ongoing evaluation of health standards, improve mission safety, and reduce risks for current and future astronauts.

This was no surprise, as the Institute of Medicine said essentially the same thing in their 2001 and 2004 studies.

I know firsthand that risks can come up unexpectedly. On July 16, 2013, I was on an extra-vehicular activity (EVA) with Luca Parmitano, when Luca had cooling water leak into his helmet, covering his face with water. We quickly and safely ended the EVA, thanks to the "buddy system" NASA has in place for EVAs, but it demonstrates that unexpected health risks can appear at any time. Who would have thought that drowning could be an issue in spaceflight?

As Chief Astronaut, charged with the safety and health of NASA astronauts, I would welcome Congressional leadership to allow NASA to better provide for the health care needs of our current and former astronauts. As someone involved in the standards for designing human spacecraft so the hardware prevents exposure to risk, I support this measure that would allow us to collect the data on human spaceflight factors we desperately need.

Mr. Chairman, I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

Biographical Data

Lyndon B. Johnson Space Center
Houston, Texas 77058



National Aeronautics and
Space Administration
January 2016

CHRISTOPHER J. CASSIDY (CAPTAIN, U.S. NAVY) NASA ASTRONAUT



video Q&A with Christopher

PERSONAL DATA: Born in 1970 in Salem, Massachusetts. Considers York, Maine, to be his hometown.

EDUCATION: Graduated from York High School, York, Maine; completed Naval Academy Prep School, Newport, Rhode Island, 1989; received a Bachelor of Science in Mathematics, U.S. Naval Academy, 1993; received a Master of Science in Ocean Engineering, Massachusetts Institute of Technology, 2000, Honorary PHD from Hussey University, 2015.

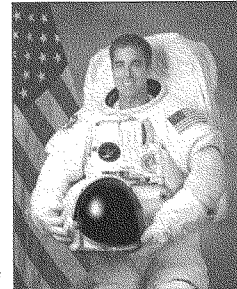
ORGANIZATIONS: U.S. Naval Academy Alumni Association; Massachusetts Institute of Technology Alumni Association; Fraternal Order of Underwater Demolition Team (UDT)/Sea, Air, Land Team (SEAL) Association.

SPECIAL HONORS: Honor graduate of Basic Underwater Demolition/SEAL (BUD/S) Class 192; awarded the Bronze Star with combat "V" and Presidential Unit Citation for leading a nine-day operation at the Zharwar Kili cave complex on the Afghanistan/Pakistan border; guest speaker at the U.S. Naval Academy Combat Leadership Seminar, 2003 & 2004; awarded a second Bronze Star for combat leadership service in Afghanistan, 2004; Recipient of NASA Exceptional Achievement Medal. Finisher in the Ironman World Championship triathlon in Kona, Hawaii, 2014.

MILITARY EXPERIENCE: Ten years as a member of the U.S. Navy SEALs Team. He made four six-month deployments: two to Afghanistan, and two to the Mediterranean. Cassidy served as Executive Officer and Operations Officer of Special Boat Team Twenty in Norfolk, Virginia, and SEAL platoon commander at SEAL Team THREE in Coronado, California. He deployed to the Afghanistan region two weeks after September 11, 2001, served as ground assault force commander for international and U.S. only combat missions in Afghanistan, and led two months of noncompliant ship-boarding in the Northern Arabian Gulf. He was SEAL Delivery Vehicle (SDV) platoon commander at SDV Team TWO in Norfolk. He accumulated more than 200 hours underwater as pilot/navigator/mission commander of a two-man flooded submersible SDV, which is launched and recovered from a host-ship submarine. He also served as dry deck shelter platoon commander at SEAL Delivery Team TWO in Norfolk. Cassidy volunteered to complete a week-long, 180-mile charity kayak paddle from Norfolk to Washington, D.C. to raise money and awareness for the Special Operations Warrior Foundation. He achieved the rank of Captain in 2014.

NASA EXPERIENCE (non-flight): Cassidy was selected as an astronaut by NASA in May 2004. In February 2006, he completed Astronaut Candidate (ASCAN) training. From 2006 through 2008, he served as Capsule Communicator (CAPCOM) in the Mission Control Center. In 2009 through 2011, Cassidy was assigned as the support astronaut on the Space Shuttle Closeout Crew tasked with strapping in the crew and closing and sealing the access hatch for flight. From 2014 to 2015, he served as the Extravehicular Activity (EVA) branch chief and in 2015 was assigned as the Deputy Chief, Astronaut Office. After serving four months as deputy, Cassidy became the 16th Chief Astronaut in July 2015.

SPACE FLIGHT EXPERIENCE: Cassidy has flown in space twice: first on STS-127 and most recently on Soyuz (TMA-08M). On STS-127, ISS assembly mission 2J/A, on Endeavour (July 15, 2009 through July 31, 2009), he served as a Mission Specialist and was the 500th person in history to fly into space. The crew delivered the Japanese-built Exposed Facility (JEM-EF) and the Experiment Logistics Module Exposed Section (ELM-ES) to the station. They completed the construction of the KIBO Japanese Experiment Module, installed scientific experiments on its exposed facility and delivered critical spare parts and replacement batteries. In 2011, Cassidy was assigned to the Expedition 35 crew as a flight engineer and flew to the ISS aboard Soyuz TMA-08M (US designation: 34S), which launched from the Baikonur Commadore in Kazakhstan on March 28, 2013. The three crew members were the first to complete an expedited docking to the station – instead of taking the standard two days to rendezvous and dock, they arrived at the orbiting complex in six hours. Cassidy has completed a total of six



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spacewalks, but two were of particular note. On May 11, 2013, Cassidy and Thomas Marshburn performed an unplanned spacewalk to replace a pump controller box suspected to be the source of an ammonia coolant leak, and on July 16, 2013, he and Luca Parmitano had their EVA cut short when Parmitano had cooling water leaking into his helmet covering his face with water. Overall, Cassidy has accumulated 31 hours, 14 minutes of EVA time and 182 days in space.

Chairman BABIN. Thank you, Captain Cassidy. I really appreciate that.

I now recognize Captain Kelly for five minutes to present his testimony.

**TESTIMONY OF CAPTAIN SCOTT KELLY
(USN, RET.),
FORMER ASTRONAUT, NASA**

Captain KELLY. And Mr. Chairman, I have a short video, if you don't mind, an introduction video.

[Video playback]

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the importance of understanding the medical impacts of human spaceflight on astronauts and the proposed legislation on astronaut health. This issue is of critical importance to me and to our nation's future space exploration initiatives.

I recently returned with my colleague, Russian Cosmonaut Mikhail Kornienko, from nearly a year in space aboard the Isa, which serves as our best asset for understanding how human physiology behaves in a microgravity environment. Until at least 2024, the Space Station will continue to provide a platform for research on astronaut health and many other scientific investigations.

The major objective of this Year in Space mission was to expand the experience and knowledge base required to safely send humans deeper into our solar system. A Mars mission is no easy feat and could require astronauts to be in space for three years or more. During this mission, we conducted more than 400 experiments in the fields of biology, material sciences, chemistry, and physics. Many of these experiments focus on how the human body responds to weightlessness and other effects of long-duration spaceflight.

One of these experiments, which was dubbed the Twins Study, gave researchers the unique opportunity to study my physiology while I was in space compared to my twin brother, retired Astronauts and Navy Captain Mark Kelly, who was on Earth. Data acquired from this Year in Space Mission will help NASA make determinations that will directly affect decisions regarding crew safety in the years to come in areas from the design of future spacecraft to medical and psychological risk mitigation. Although I've been home for 100 days, much of the data is still being analyzed by researchers from around the world.

You know, much attention is paid to the risks astronauts face while launching aboard rockets or returning to Earth in a giant fireball. Much less attention is given to the other risks we face, which are much more insidious but potentially just as fatal. The environment astronauts are exposed to while in space is unlike anything we experience here on Earth. Specifically, we're exposed to high levels of radiation and carbon dioxide, and a microgravity environment which causes loss of bone and muscle, vision impairment, and effects on our immune system, to name just a few. These are very real issues that need to be solved before the human race is able to reach destinations beyond the Earth and the Moon.

When I returned after 340 days, I was surprised how differently I felt compared to my long-duration mission of 159 days. My mus-

cles more quickly stiffened, and because my skin hadn't touched anything for nearly a year, it was extremely sensitive and became inflamed. I developed a hive-like rash on every surface of my skin that came in contact with ordinary surfaces on Earth during normal activities like sitting or lying in bed. My legs were swollen due to the fluid shift imposed upon my body by gravity. I even had flu-like symptoms that appeared to have been a result from my extended time in space.

Exposure to the space environment has permanent effects we simply do not fully understand. The Lifetime Surveillance of Astronaut Health program NASA has in place to study astronaut long-term health is too limited to provide the data needed to ensure the safety of our space explorers. If we are to go beyond low-Earth orbit, NASA needs the ability to proactively and aggressively monitor, diagnose and treat astronauts who serve our country in the name of science and exploration. Expanding healthcare coverage for our U.S. Astronaut Corps will enable NASA to more effectively and efficiently support it and collect the data necessary to push out further into our solar system.

Furthermore, continued investigation of space-related ailments and mitigation steps will help in treating similar ailments on Earth such as osteoporosis, muscle wasting diseases, high blood pressure, glaucoma, and certain brain disease, to name just a few. There are already FDA-approved treatment modalities which are a result of space-based research.

Although Mars and other long-term NASA objectives seem to be many years ahead of us, laying a secure foundation for astronaut health is imperative to the continuance of our nation's ability to explore. Healthcare for our astronauts is critically important. Our astronauts are exposed to numerous health risk factors while in space, and while we are aware of some of the impacts, we just need more data from astronauts in space and on the ground to better understand these negative effects of this harsh environment.

The proposed legislation on astronauts health will not only help us learn more about the impacts of human spaceflight but also will serve to protect the health of those who push the boundaries in the name of exploration on behalf of our nation. We are on the cusp of a new Space Age, one in which greater numbers of Americans will travel to space and go further than ever before.

I was honored to play a small role in paving the way for those future pioneers but want to make it clear, this Year in Space mission was not my achievement; it was the achievement of thousands of dedicated professionals that believe, like I do, that the benefit of human spaceflight is vital to the continued success and development of our nation and our species.

Mr. Chairman, I'd be happy to respond to any questions you or other members of the Subcommittee may have. Thank you.

[The prepared statement of Captain Kelly follows:]

HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
June 15, 2016

**Statement of
Scott Kelly
Retired Astronaut
National Aeronautics and Space Administration**

before the

**Subcommittee on Space
Committee on Science, Space and Technology
U. S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the importance of understanding the medical impacts of human space flight on astronauts and the proposed legislation on astronaut health. This issue is of critical importance to me and to our nation's future space exploration initiatives.

I recently returned with my colleague Russian Cosmonaut Mikhail Kornienko from nearly a year in space aboard the International Space Station which serves as our best asset for understanding how human physiology behaves in a microgravity environment. Until at least 2024 the space station will continue to provide a platform for research on astronaut health and many other scientific investigations.

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environment which causes loss of bone and muscle, vision impairment and effects on our immune system to name just a few. These are very real issues that need to be solved before the human race is able to reach destinations beyond the Earth and Moon.

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Although Mars and other long-term NASA objectives seem to be many years ahead of us, laying a secure foundation for astronaut health is imperative to the continuance of our nation's ability to explore. Healthcare for our astronauts is critically important. Our astronauts are exposed to numerous health risk factors while in space and while we are aware of some of the impacts we need more data from astronauts in space and on the ground to better understand the negative effects the harsh microgravity environment of space has on the human body.

The proposed legislation on astronaut health will not only help us learn more about the impacts of human spaceflight but also will serve to protect the health of those who push the boundaries in the name of exploration on behalf of our nation.

We are on the cusp of a new space age – one in which greater numbers of Americans will travel to space and go farther than ever before. I was honored to play a small role in paving the way for those future pioneers but want to make it clear this Year in Space mission was not my achievement. It was the achievement of thousands of dedicated professionals that believe like I do that the benefits of human spaceflight are vital to the continued success and development of our nation and our species.

Mr. Chairman, I would be happy to respond to any questions you or the other Members of the Subcommittee may have.

Biographical Data

Lyndon B. Johnson Space Center
Houston, Texas 77058



National Aeronautics and
Space Administration
February 2016

SCOTT J. KELLY (CAPTAIN, USN, RET.)
NASA ASTRONAUT

Pronunciation: SKOT KEH-lee



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PERSONAL DATA: Born February 21, 1964 in Orange, New Jersey. He has two children.

EDUCATION: Graduated from Mountain High School, West Orange, New Jersey, in 1982; received a Bachelor of Science degree in Electrical Engineering from the State University of New York Maritime College in 1987 and a Master of Science degree in Aviation Systems from the University of Tennessee, Knoxville, in 1996.

ORGANIZATIONS: Associate Fellow, Society of Experimental Test Pilots; Member, Association of Space Explorers

SPECIAL HONORS: Two Defense Superior Service Medals, Legion of Merit, Distinguished Flying Cross, Navy Commendation Medal, Navy Achievement Medal, two Navy Unit Commendations, National Defense Service Medal, Southwest Asia Service Medal, Kuwait Liberation Medal, Sea Service Deployment Ribbon, NASA Distinguished Service Medal, NASA Exceptional Service Medal, NASA Outstanding Leadership Medal, three NASA Space Flight Medals, Russian Federation Medal for merit in Space Exploration, Korolev Diploma from the Federation Aeronautique Internationale, 1999. Honorary Doctorate of Science degree from the State University of New York, 2008.

EXPERIENCE: Kelly received his commission from the State University of New York Maritime College in May 1987 and was designated a naval aviator in July 1989 at Naval Air Station (NAS) in Beeville, Texas. He then reported to Fighter Squadron 101 at NAS Oceana, Virginia Beach, Virginia, for initial F-14 Tomcat training. Upon completion of this training, he was assigned to Fighter Squadron 143 and made overseas deployments to the North Atlantic, Mediterranean Sea, Red Sea and Persian Gulf aboard the USS Dwight D. Eisenhower (CVN-69). Kelly was selected to attend the U.S. Naval Test Pilot School in January 1993 and completed training in June 1994. After graduation, he worked as a test pilot at the Strike Aircraft Test Squadron, Naval Air Warfare Center, Aircraft Division, Patuxent River, Maryland, flying the F-14 Tomcat and F/A-18 Hornet. Kelly was the first pilot to fly an F-14 with an experimental digital flight control system installed and performed subsequent high angle of attack and departure testing. He has logged over 8,000 hours in more than 40 different aircraft and spacecraft and has over 250 carrier landings. Kelly holds a United States Coast Guard Third Mate's license. Kelly retired from the U.S. Navy in June of 2012.

NASA EXPERIENCE: Selected by NASA in April 1996, Kelly reported to the Johnson Space Center in August 1996. Following completion of training, he was assigned technical duties in the Astronaut Office Spacecraft Systems/Operations branch. Kelly has logged more than 520 days in space on four space flight, and currently holds the record for time in orbit by a U.S. Astronaut. He served as Space Shuttle pilot on STS-103 in 1999 and was the Mission Commander on STS-118 in 2007. Following STS-103, Kelly served as NASA's Director of Operations in Star City, Russia. He served as a backup crewmember for International Space Station (ISS) Expedition 5 and as the Astronaut Office Space Station Branch Chief. Kelly also served as a Flight Engineer for ISS Expedition 25 and as the Commander of ISS Expedition 26. In March 2015, Kelly launched for a one-year mission to the ISS, serving as a Flight Engineer for increments 43 and 44, and Commander for increments 45 and 46.

SPACEFLIGHT EXPERIENCE: STS-103 (December 19 to December 27, 1999) was an 8-day mission, during which the crew successfully installed new instruments and upgraded systems on the Hubble Space Telescope (HST). Enhancing HST scientific capabilities required three spacewalks (EVAs). The STS-103 mission was accomplished in 120 Earth orbits, traveling 3.2 million miles in 191 hours and 11 minutes.

STS-118 (August 8 to August 21, 2007) was the 119th space shuttle flight, the 22nd flight to the ISS, and the 20th flight for Endeavour. During the mission, Endeavour's crew successfully added another truss segment, a new gyroscope and an external spare parts platform to the ISS. A new system that enables docked shuttles to draw electrical power from the station to extend visits to the outpost was successfully activated. A total of four EVAs were performed by three crewmembers. Endeavour carried approximately 5,000 pounds of equipment and supplies to the station and returned to Earth with approximately 4,000 pounds of hardware and equipment. Traveling 5.3 million miles in space, the STS-118 mission was completed in 12 days, 17 hours, 55 minutes and 34 seconds.

Kelly launched aboard the Soyuz TMA-M spacecraft on October 7, 2010 to serve a tour of duty on the ISS. He assumed command of Expedition 26 once the Soyuz TMA-19 undocked on November 24, 2010. After a 159 day stay aboard the ISS, Commander Kelly and Russian Flight Engineers Alexander Kaleri and Oleg Skripochka safely landed their Soyuz spacecraft on the Kazakhstan Steppe on March 16, 2011.

Kelly and cosmonaut Mikhail Kornienko launched in March 2015 for a year-long mission to the International Space Station. The mission's goal is to understand how the human body reacts and adapts to the harsh environment of space. During the 340-day mission, almost 400 experiments were conducted on the station. Data from the expedition will be used to reduce risks to the health of crewmembers as NASA prepares to advance space travel beyond low Earth orbit. Kelly was a Flight Engineer for increments 43 and 44, and the International Space Station Commander for increments 45 and 46. Kelly's year in space included 5,440 orbits around the Earth and he conducted three spacewalks before returning home in March 2016.

Scott Kelly retired from NASA March 2016.

Chairman BABIN. Thank you, Captain Kelly. We really appreciate your testimony.

And now I recognize Captain Lopez-Alegria for five minutes.

**TESTIMONY OF CAPTAIN MICHAEL LOPEZ-ALEGRIA (USN,
RET),
PRESIDENT, ASSOCIATION OF SPACE EXPLORERS-USA;
FORMER ASTRONAUT, NASA**

Captain LOPEZ-ALEGRIA. That's all right. Thanks, Chairman Babin, Ranking Member Edwards, and Chairman Smith, and Ranking Member Johnson and all the Members of the Subcommittee. Thanks for organizing this hearing and for asking me to give you some comments on the proposed legislative language as the President of the USA Chapter of the Association of Space Explorers.

ASE is an international nonprofit professional and educational organization that has only one prerequisite for membership: having made at least one orbit of the Earth in space. Our vision is a world where living, working and exploring in space will be as familiar to humanity as life on our home planet.

We count among our members over 400 current and former astronauts and cosmonauts from 37 nations and are organized into four regional chapters: Russia, Europe, Asia, and ASE-USA, by far the largest with 214 living members.

There's a standing joke at the NASA Johnson Space Center in Houston that if you ask five astronauts for their opinion on an issue, you'll get at least six answers. Nonetheless, the response I received from the membership of ASE-USA was absolute unanimity in support of the change that would allow NASA to provide enhanced monitoring, diagnosis, and treatment of the effects of health hazards that are associated with having flown in space.

I heard from former astronauts who left the agency from several months to several decades ago, and many of the stories were strikingly similar. My written statement mentions some of the known health hazards that are unique to the spaceflight environment, and members of the ASE-USA convincingly confirmed that that list is real with many personal accounts of musculoskeletal, vision, bone density, and most grimly, cancer-related medical issues.

In some case, their maladies were flagged during annual exams that are offered by NASA as part of the Lifetime Surveillance of Astronaut Health but in all cases, further diagnosis and any treatment is at the expense of the astronaut. There is ample precedent for targeted surveillance and treatment for occupationally related medical conditions both within the government, for instance, healthcare for veterans as well as screening for DOE and DOD nuclear workers as well as by non-government employers for their workers in mines, foundries, and in civilian nuclear power industry.

But as compelling as some of my former colleagues' medical situations are, the most persuasive argument for this type of legislation is that understanding the human physiological response to spaceflight is imperative to inform future policies and procedures for managing health risks in space.

In the absence of methodical medical surveillance and care for those exposed to these health risks, we are irretrievably losing an invaluable source of data and severely hampering our plans to extend human exploration beyond low-Earth orbit.

The current and former astronaut cadre is the only study population that can facilitate our understanding of past and future space-related health risks. It is unforgivable to not monitor their health and collect and analyze the relevant associated data.

I'm a participant in a previously mentioned LSAH. Each year I travel to Houston and receive a medical check that includes collecting my vital signs, blood and urine samples, exams of my vision, hearing, and lung function, an EKG, and a brief physical exam by a flight surgeon. Every few years, it is recommended that I undergo a colonoscopy to look for polyps or tumors that may have appeared as a result of my exposure to ionizing radiation while on orbit. The procedure is completely voluntary, and if I do choose to have it done, the results are not a priori shared with NASA. This is just one example of the lack of monitoring that negatively affects our understanding of the epidemiology of spaceflight.

Another valuable test that might be performed is high-powered MRI of my eyes to look for anatomical changes. Like about 60 percent of long-duration astronauts, I suffer from microgravity ocular syndrome, sometimes called vision impairment and intracranial pressure. VIIP is emerging as one of the most significant and least understood health risks for human exploration beyond low-Earth orbit. It seems absurd that we do not actively study those who have suffered from it.

During my seven months aboard the ISS, my bone mineral density decreased by over ten percent. While the density itself recovered after a couple of years, we don't fully understand if the structure of the bone and therefore its resistance to fracture has returned. A test like QCT, quantitative computed tomography, cannot only measure bone mineral density but also assess the geometry of the bone and the stress-strain index, a much better measure of fracture resistance. This test is also not performed as part of LSAH.

What I found perhaps most startling in responses from the ASE-USA membership was how many reported that they have dropped out of the LSAH program. A relatively routine physical that lacks targeted surveillance of known space-related health hazards, let alone any kind of in-depth diagnosis or provision of treatment, is simply not compelling enough for many former astronauts who might live far from Houston to take time from work and family to make the trip. This means that not only is NASA deprived of any data related to spaceflight-specific health risks, even the routine surveillance that is part of today's LSAH is often being done by local medical providers and the associated information is lost to NASA.

There is a moral and ethical obligation on the part of any employer to exercise due diligence to study all occupational hazards that its employees encounter in the workplace to understand the short- and long-term health effects of those dangers to use all reasonable methods to prevent these risks from negatively impacting the well-being of its current and future workers and to provide care

for former employees who suffer health issues as a result of their service.

There are a number of significant human health risks associated with flying in space. Many of these perils are unique to the spaceflight environment and most evade our full understanding. It's clear that we must do our utmost to mitigate these risks for the cadre of current and future American astronauts by assiduously monitoring the health and, where applicable, treatment of their predecessors. This information is absolutely imperative for the design of missions, vehicles, and countermeasures for the human exploration of space beyond low-Earth orbit.

Thank you again for this opportunity, and I look forward to answering questions from the Subcommittee.

[The prepared statement of Captain Lopez-Alegria follows:]

**Human Spaceflight Ethics and Obligations:
Options for Monitoring, Diagnosing and Treating Former Astronauts
Statement of Michael Lopez-Alegria
President, ASE-USA**

INTRODUCTION

The Association of Space Explorers is an international nonprofit professional and educational organization that has only one prerequisite for membership – having made at least one orbit of the Earth in space. It was founded in 1985 by a small group of fliers from the U.S., the Soviet Union and other countries. Our vision is a world where living, working, and exploring in space will be as familiar to humanity as life on our home planet. We apply the unique perspective of our membership to promote the global benefits of space science, exploration and international cooperation; to educate and inspire future generations; and to foster better stewardship of our home planet. We count among our members over 400 current and former astronauts and cosmonauts from 37 nations, and are organized into four regional chapters - Russia, Europe, Asia, and ASE-USA. The latter is by far the largest, with 214 living members.

BACKGROUND

There is no doubt that human spaceflight is a risky endeavor. Statistical analysis shows that astronauts who fly to and from the ISS aboard a Soyuz spacecraft and spend six months there have a threat of mortality comparable to those of U.S. infantry combatants on D-Day and New York City firefighters on 9/11. Americans engaged in other dangerous professions, such as crop dusting pilots, timber cutters, construction workers and coal miners, are at least an order of magnitude less likely to lose their lives on the job.

The greatest risk during spaceflight is incurred during the dynamic phases of launch and reentry. Massive amounts of energy are focused to propel the spacecraft in the intended direction during launch and insertion, and the same energy must later be carefully and precisely shed for deorbit and landing. NASA spends significant resources to understand and mitigate the risks associated with these stages of flight, as well as to grapple with the primary peril once in orbit – an encounter with micrometeoroid orbital debris. As more experience is accrued, lessons are learned and the effectiveness in managing those risks increases.

PROBLEM STATEMENT

The impact of exposure to health hazards in the unique environment of spaceflight is a far less understood danger. These risks include long-observed phenomena like ionizing radiation, weightlessness, with its attendant loss of bone mineral density, noise and toxic exposures, and as well as more recently detected issues like microgravity ocular syndrome. Just as systematic assessment of the mechanical hazards to spacecraft during launch, landing and on orbit is an indispensable tool in the management of technical risk, a thorough grasp of the short- and long-

term human physiological response to spaceflight is imperative to inform future policies and procedures for managing health risk. Unfortunately, no comprehensive occupational medical surveillance program for NASA astronauts exists today. In the absence of methodical medical surveillance and care for those exposed to these health risks, we are irretrievably losing an invaluable source of data, and are severely hampering our plans to extend human presence beyond low Earth orbit. The former and current astronaut cadre is the only study population that can facilitate our understanding of past and future space-related health risks; it is unforgivable to not monitor their health, and collect and analyze the relevant associated data.

PROPOSED SOLUTION

The nation needs a dedicated astronaut occupational medical program, oriented toward surveillance for effects of the health risks associated with spaceflight and the diagnosis and treatment of resulting health consequences. Such programs exist for the nuclear workers of the Department of Energy, the Department of Defense, and the civil nuclear power industry. The DOE's Former Worker Medical Screening Program provides ongoing medical screening examinations, at no cost, to all former DOE federal, contractor, and subcontractor workers who may be at risk for occupational diseases (National Defense Authorization Act 1993; FWP Office of Health, Safety, and Security). Workers are monitored carefully for radiation doses acquired during their work careers, and undergo medical surveillance following retirement for health effects that may be causally related to their occupational radiation exposures. Similarly, workers exposed to industrial dusts, such as miners and foundry workers, are monitored for known diseases whose incidences increase due to these exposures. Both the operation of target organ systems – lung function in this case – and resulting illnesses, including asbestosis, mesothelioma, and silicosis, are followed. It is important to monitor both for function of target organs at risk as well as the known specific illness tied to these risks. In these industries, there is a recognized obligation to provide both comprehensive monitoring and health care for risks attributable to the workplace. Similarly, NASA has a moral and ethical obligation to provide appropriate long-term surveillance, diagnostic and therapeutic support to current and former astronauts for health conditions related to their work environment, as well as to facilitate the expansion of human exploration beyond low Earth orbit.

HUMAN HEALTH HAZARDS IN SPACEFLIGHT

Radiation

Ionizing radiation is a fundamental aspect of the space environment, with exposure levels much higher than those encountered in any natural terrestrial setting. Astronauts are exposed to a complex milieu of radiation that differs qualitatively and quantitatively from terrestrial radiation sources. Space sources include Earth's geomagnetic fields, solar particles, and galactic cosmic rays (GCR), as well as secondary particles produced when high energy ions impact spacecraft and habitat structures (Operational Radiation Safety Program NCRP Report 142). With the energies and spectra encountered in spaceflight, radiation is and most likely will continue to be the major limitation to human space exploration for the foreseeable future.

Ionizing radiation is known to have many deleterious effects on human health. The combination of the wide spectrum of radiation types and energies inherent in spaceflight together with the negative effect on human health make this an especially complex hazard. It is important to emphasize that the radiation health hazard impacts nearly all aspects of human spaceflight, including vehicle and habitat design, mission duration, exploration mission architecture, crew selection, and monitoring. Although human spaceflight currently operates in a radiation risk zone that has not demonstrated immediate negative health impacts from these radiation exposures, adverse effects may take many years to emerge. These risks require long term statistical analysis of flight crew populations to identify and document medical risks from space radiation.

The main medical risks associated with the spaceflight radiation exposure include increased cancer risk, degenerative tissue disease, and possible central nervous system effects. In particular, increased incidence of cancer is a well-known consequence of radiation exposures. Currently, U.S. astronauts work under a career exposure limit that corresponds to a 3% predicted increase in cancer death, tracked as a Risk of Exposure Induced Death (REID). The radiation dose corresponding with the 3% risk is individualized, and is gender and age weighted based on extrapolated data from ground populations. Models used to determine risk levels are still very developmental, and there is considerable uncertainty in predicting consequences of a specific space radiation exposure. Uncertainty is reduced by applying conservative scaling factors. However, the uncertainties of models, combined with conservative scaling factors and limits as applied to actual radiation doses encountered, profoundly affect both individual flight careers and future exploration scenarios.

Astronauts are meticulously monitored for acquired radiation dose during their active flight careers, similar to terrestrial radiation workers. However, the U.S. Government does not provide long term screening to astronauts or treatment for illness which may be space radiation related. This lack of monitoring negatively affects our understanding of the epidemiology of spaceflight, since some of these cancers may not be captured without long term surveillance following active flight careers. Most importantly, survival from most types of cancers is highly dependent on the stage of disease at diagnosis. If a long term screening program similar to what has been implemented in other sectors of government is not in place, astronauts risk later detection and thus worse outcomes of any radiation related cancers. Additionally, there is evidence that radiation induced cancers may be more aggressive than their non-radiation associated counterparts. Clearly, a comprehensive and aggressive lifetime screening program for radiation induced or enhanced cancers is obligatory to find, treat and understand cancers caused by space radiation. Such a program will identify likely cancer types and screening schedules to optimize long term health outcomes. This knowledge base will be systematically built, and will be applied to REID endpoints to determine if radiation limits can be safely increased.

Other radiation health effects are known; however, their relationship to spaceflight radiation exposure is even less quantifiable than cancer. Degenerative tissue diseases associated with ionizing radiation include cataracts, cardiovascular disease, and gastrointestinal disease (Little et al. 2012). Although these issues and diseases have been identified in ground populations exposed to radiation, space flight limits cannot yet be defined due to multiple confounding factors. Likewise, animal studies suggest that long term central nervous system effects, including dementia, Alzheimer's disease, and premature aging, may be associated with large doses of

ionizing radiation (Cucinotta, 2012). Much more research is needed to determine actual relationships and mechanistic contributions. However, it is prudent to perform long-term health screening of astronauts for degenerative tissue diseases and central nervous system effects.

Microgravity Ocular Syndrome (Visual Impairment and Intracranial Pressure - VIIP)

In the past few years, a constellation of findings associated with weightlessness involving eye structures and the central nervous system has been identified. The overall syndrome involves swelling of the optic nerve head (optic disc) of the retina, swelling and distension of the optic nerve sheath behind the eye, flattening of the globe of the eye causing a hyperopic vision shift, and small but significant increases in intracranial pressure (ICP). Subjectively, crewmembers note only degradation of visual acuity, with near vision worsening over time on orbit and requiring stronger corrective lenses (Mader et al., 2011). Prevalence of this syndrome is high, exceeding 50% in long duration flyers, with a strong male predominance. Subtle changes have been seen even in astronauts after short duration Space Shuttle missions (Kramer et al., 2012). Determination of ICP involves performing a spinal tap, and this has been done in only a small number of crewmembers postflight. In spite of the anatomical findings seen, crewmembers are not functionally impaired with adequate vision correction; as such, routine performance of spinal taps is not clinically justified. However, indirect findings based on imagery do suggest a small to moderate increase in ICP in the majority of individuals. Currently, there is no direct knowledge about ICP inflight. These vision and anatomical changes may persist in some astronauts postflight, suggesting permanent tissue remodeling.

Microgravity ocular syndrome likely involves adaptive responses to weightlessness that have not yet been recognized, and is one of the most significant physiologic discoveries in human spaceflight. Although only recently recognized, this syndrome is almost certainly not new. Anecdotal reports of vision shifts have been noted for decades among U.S. and other crewmembers. Russian medical specialists noted optic disc swelling in postflight examinations of long duration crewmembers following Mir missions. However, modern diagnostic tools have helped to bring the magnitude of this issue to light. These tools include 3-Tesla magnetic resonance imaging, optical coherence tomography, high definition retinal imagery, and optical ultrasound, the latter two of which may now be performed inflight. The cause and mechanism of microgravity ocular syndrome remain unclear, and are the focus of intensive investigation. A driving factor is most likely the headward fluid shift that occurs in weightlessness, along with other changes in vascular and fluid regulation. Additional factors being studied include high carbon dioxide levels found on spacecraft, heavy resistive exercise, and possible individual metabolic characteristics (Bowman et al., 2013).

Musculoskeletal Injury

Musculoskeletal injuries are occupational risks astronauts face throughout their careers. These injuries often result from daily cardiovascular and weight training, both on the ground and on-orbit. Prior to flight and typically over a period of several years, extensive training is required for astronauts to effectively perform the required tasks needed for space walks, or EVA (extravehicular activity) in a pressurized space suit. In space, daily two-hour exercise sessions are required to counter bone and muscle losses caused by microgravity.

Musculoskeletal injuries are also directly related to the EVA training, which is performed in the spacesuit in the Neutral Buoyancy Lab (NBL). This underwater simulation permits crew members to practice the actual hands-on maneuvers, but requires use of heavy tools, performance of overhead tasks, and working in inverted positions in a 300 pound spacesuit. The suit design results in impingement on the shoulder, specifically limiting scapulothoracic motion. Numerous 6-hour training sessions in a pressurized suit have resulted in a variety of musculoskeletal injuries. Rotator cuff tears, tendonitis, bursitis, and labral tears of the shoulder are common (Viegas et al., 2004). Elbow injuries are also common and include medial and lateral epicondylitis. Since 2002, there have been over 100 cases of shoulder injury, more than a dozen of which required surgical repair, along with several elbow injuries which have required surgery (Scheuring et al., 2009). This training is an occupational hazard with complications that may persist long after employment.

Postflight, astronauts are also at risk of spinal herniated nucleus pulposus (HNP), commonly known as herniated disc. In the immediate 12-month postflight time period, the incidence of both cervical and lumbar HNP is 4.3 times higher in the astronaut population than in controls (Johnston et al., 2010). This is believed to be related to expansion of intervertebral discs during axial unloading in weightlessness. Approximately one quarter of the astronauts with a diagnosis of HNP in the study ultimately required cervical or lumbar surgery.

The extensive history of musculoskeletal injury requiring surgical repair indicates that long term follow up is required to fully understand the impacts of training and spaceflight on crew members. This follow up will also provide valuable information about spacesuit design and countermeasures to prevent injury.

Changes in Bone

Loss of bone mineral density caused by spaceflight is well documented. Detailed studies have determined that microgravity enhances the bone resorption (breakdown) process, particularly in weight-bearing bone structure. Unfortunately, in microgravity, this process is uncoupled from bone formation (Sibonga et al., 2008). The spaceflight average loss for crew members is 1-1.5% bone mineral density per month. This is significantly greater than the rate of bone loss seen in older individuals on earth, on the order of 0.5% to 1.0% per year (Orwoll et al., 2013). The mechanism of imbalance between bone resorption and formation during spaceflight is now understood based on measurement of various biochemical bone markers of bone formation and resorption. In addition to bone mineral density loss, there are also changes in subcompartment bone as shown by quantitative computed tomography (Carpenter et al., 2010). Mechanical analysis of the bone data suggests that hip strength is reduced after 6-month spaceflight missions (Seemen et al., 2001; Sibonga et al., 2008). These bone changes are significant. To date, two crew members have suffered hip fractures 15-18 months after returning from long duration spaceflight.

Countermeasures to minimize these bone mineral density losses during spaceflight include heavy resistive exercise, bisphosphonate drugs, and nutritional supplementation. Improved exercise hardware (Advanced Resistive Exercise Device (ARED) and advanced treadmill) together with bisphosphonates and better nutritional management have demonstrated improvement in astronaut

bone density over previous countermeasures. However, ongoing detailed studies are necessary to understand the complexities of bone quality and the ability to recover bone strength after spaceflight. In addition, there is the added risk of providing bisphosphonates to a population that is younger than the age group these drugs were designed to help, which may cause unanticipated long term health impacts to the astronaut population.

Occupational Exposure to Substances

Historically, astronauts have been exposed to a variety of toxic materials, including formaldehyde (Shuttle, MIR, ISS), urine pre-treat solution containing sulfuric acid and hexavalent chromium (ISS), cadmium (ISS water supply), combustion event contaminants (MIR), ethylene glycol (MIR), methanol (ISS), iodine (STS-1 through 85), nitrogen tetroxide (Apollo Soyuz Test Project), mold (MIR, ISS), Freons and other halocarbons, CO₂ and CO. In some cases, degradation of life support equipment over time has resulted in crew exposure to significantly higher levels of trace impurities, for example total organic carbon in the water (ISS). Obviously, these exposures occur in a closed environmental system that the crew cannot leave and must remain in until mission conclusion, despite residual levels of toxic components. Typically, the levels of the contaminants are managed based on toxicity or criticality, likelihood of occurrence, and ability to “scrub” the environment after a toxic event.

While some occupational exposures to this list of chemicals may result in short-term effects, such as chemical burns from urine pre-treat solution or airway irritation from exposure to ethylene glycol, chronic effects require an occupational surveillance program specifically targeting suspected potential outcomes from specific exposures. For instance, formaldehyde exposure has been associated with a greater risk for nasopharyngeal and lung cancer; elevated cadmium levels are associated with chronic kidney disease.

Since these exposures occur in concert with decreased immune function and exposure to ionizing radiation, it is challenging to isolate the impact of specific toxic events. Other government agencies (DOE) provide congressionally-mandated programs to screen for potential adverse health effects for some of these sorts of substances.

Immune System Effects

The immune system is adversely affected by spaceflight (Gueguinou et al., 2009). Recent studies have identified quantifiable changes in immune function, including T cell, natural killer cell, monocyte and neutrophil function, cytokine production patterns, and latent viral reactivation. Factors which may contribute to altered immune response during spaceflight include radiation, physical and psychological stress, persistent circadian misalignment, nutritional deficiencies including antioxidants and vitamin D, and air quality and particulate levels. Microgravity may also directly suppress immune function. Additionally, some microbes may become more virulent in microgravity. Here on Earth, immune system problems can contribute to increased incidence of infection, allergies, hypersensitivities, autoimmunity and increased risk of tumor formation.

Crewmembers have experienced allergic symptoms and rashes during spaceflight which may be related to altered immune responses. Crewmembers who have no allergies on Earth have suffered sneezing and itchy eyes that required daily allergy medication for their entire long-duration mission. The incidence of rashes during spaceflight is 75 times greater than on Earth (Ilcus et al., 2009). These rashes can persist for months, and resist effective treatment. In addition, delayed healing from cuts and scrapes has also been reported.

These observations are consistent with scientific data that demonstrate alterations in immune function during spaceflight. However, consequences to long term crew health are not known. While further research is necessary to determine the actual risk levels for astronauts during spaceflight, these potential clinical outcomes could have either acute or chronic impacts on long duration missions (Crucian et al., 2009), along with long-term effects on occupational health.

SUMMARY

There is a moral and ethical obligation on the part of any employer to exercise due diligence to study all occupational hazards that its employees may encounter in the workplace, to understand the short- and long-term health effects of those dangers, to use all reasonable methods to prevent these risks from negatively impacting the wellbeing of its current and future workers, and to provide care for former employees who suffer health issues as a result of their service. There are a number of significant human health risks associated with flying in space, in addition to the considerable physical hazards of dynamic flight phases. Many of these perils are unique to the spaceflight environment and most evade our full understanding. It is clear that we must do our utmost to mitigate these risks for the cadre of current and future American astronauts by assiduously monitoring the health and, where applicable, treatment of their predecessors. This information is absolutely imperative for the design of missions, vehicles and countermeasures for exploration of space beyond low Earth orbit. Finally, there is a public right to understand the comprehensive effects of spaceflight on human health as the democratization of access to space becomes a reality with the successes of commercial human spaceflight.

REFERENCES

- Carpenter RD, LeBlanc AD, Evans H, et al. Long-term changes in the density and structure of the human hip and spine after long-duration spaceflight. *Acta Astronautica* 2010; 67: 71-81.
- Cucinotta F, Wang H, Huff J. Risk of Acute or Late Central Nervous System Effects from radiation Exposure. Human Research Program / Human Research Roadmap Evidence Report, Chapter 6. 2012 <http://humanresearchroadmap.nasa.gov/Evidence/reports/CNS.pdf>
- Crucian B, Sams C. Immune system dysregulation during spaceflight: clinical risk for exploration-class missions. *J Leukoc Biol* 2009;86(5):1017-8.
- Former Worker Medical Screening Program, Office of Health, Safety, and Security. <http://www.hss.energy.gov/healthsafety/fwsp/formerworkermed/>
- Gueguinou N, Huin-Schohn C, Bascove M, Bueb JL, Tschirhart E, Legrand-Frossi C, et al. Could spaceflight-associated immune system weakening preclude the expansion of human presence beyond Earth's orbit? *J Leukoc Biol* 2009;86(5):1027-38.
- Ilcus, L., Johnston, S., Moynihan, S., Kerstman, E., and Marshall, G. Rashes and Exanthems on Long Duration Space Flights. 80th Annual Scientific Meeting of the Aerospace Medical Association, 3 - 7 May 2009. California, United States.
- Johnston S, et al. Risk of Herniated Nucleus Propulsus Among U.S. Astronauts. *Aviation, Space, and Environmental Medicine* 2010;81(6):566-574
- Kramer L, Sargsyan A, Hasan K, Polk J, Hamilton D. Orbital and intracranial effects of microgravity: findings at 3-T MR Imaging. *Radiology* 263 (3) (2012) 819–827. (Epub 2012 Mar 13).
- Little MP, Azizova TV, Bazyka D, Bouffler SD, Cardis E, Chekin S, et al. 2012. Systematic review and meta-analysis of circulatory disease from exposure to low-level ionizing radiation and estimates of potential population mortality risks. *Environ Health Perspect* 120:1503–1511.
- Mader, Gibson, Pass, et al. Optic Disc Edema, Globe Flattening, Choroidal Folds, and Hyperopic Shifts Observed in Astronauts after Long-Duration Space Flight. *Ophthalmology* 2011; 118:2058-69.
- Marshall-Bowman K, Barratt M, Gibson C. Ophthalmic changes and increased intracranial pressure associated with long duration spaceflight: An emerging understanding. *Acta Astronautica* Vol. 87, June-July 2013, pp. 77-87
- National Defense Authorization Act 1993, PL 102-484; TITLE 50 CHAPTER 42 SUBCHAPTER VI Part C 2733; Program to monitor Department of Energy workers exposed to hazardous and radioactive substances

Operational radiation safety program for astronauts in low-earth orbit: a basis framework. NCRP Report No. 142; 2002. Available at: <http://www.ncrppublications.org/index.cfm?fm=Product.AddToCart&pid=8877679252>.

Orwoll ES, Adler RA, Amin S, et al. Skeletal health in long-duration astronauts: nature, assessment, and management recommendations from the NASA Bone Summit. *J Bone Miner Res*. 2013 Jun;28(6):1243-55.

Scheuring R, Mathers C, Jones J, Wear M. Musculoskeletal Injuries and Minor Trauma in Space: Incidence and Injury Mechanisms in U.S. Astronauts. *Aviation, Space, and Environmental Medicine* 2009; 80(2):117-124

Seeman E, Delmas PD. Bone Quality-The material and structural basis of bone strength and fragility. *N Engl J Med* 2001; 354: 2250-2261.

Sibonga JD, Evans HJ, Sung HG, et al. Recovery of spaceflight-induced bone loss: Bone mineral density after long-duration missions as fitted with an exponential function. *Bone* 2007; 41:973-978.

Viegas S, et al. Physical Demands and Injuries to the Upper Extremity Associated With the Space Program. *The Journal of Hand Surgery* 2004; 29A(3):359-366

CAPT Michael Lopez-Alegria, USN (Ret.)

Michael Lopez-Alegria has over thirty-five years of aviation and space experience with the U.S. Navy and NASA in a variety of roles including Naval Aviator, engineering test pilot and program manager, NASA astronaut, and International Space Station commander. He is a four-time astronaut, having flown on Space Shuttle missions STS-73, STS-92, and STS-113, and serving as Commander of ISS Expedition 14 (flying to and from the ISS aboard Soyuz TMA-9). He holds NASA records for most Extravehicular Activities (EVA) or "space walks" (10) and cumulative EVA time (67 hours 40 minutes). Lopez-Alegria is the former President of the Commercial Spaceflight Federation, where he was a spokesman, thought leader and advocate with the U.S. Congress and pertinent Executive Agencies for favorable public policy on behalf of the commercial spaceflight industry. He is now an independent consultant to traditional and commercial space companies, and serves on several advisory boards and committees of public and private organizations, including the Human Exploration and Operations Committee of the NASA Advisory Council and the Commercial Space Transportation Advisory Committee to the FAA. Lopez-Alegria is the President of the Association of Space Explorers USA, a professional and educational organization of current and former astronauts.

Chairman BABIN. Thank you, Dr. Lopez-Alegria.
And now I recognize Dr. Kahn for five minutes.

**TESTIMONY OF DR. JEFFREY KAHN,
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AND EXPLORATION SPACEFLIGHTS,
BOARD ON HEALTH SCIENCES POLICY,
NATIONAL ACADEMIES OF SCIENCES**

Mr. KAHN. Thank you. Chairman Babin, Ranking Member Edwards, Committee Chairman Smith, and Ranking Member Johnson, thank you for the opportunity to present testimony on this timely and vitally important subject today. I am a Professor of Bioethics and Public Policy at the Johns Hopkins University Berman Institute of Bioethics in Baltimore, and I should say after the introduction of my fellow witnesses, a rank underachiever.

I appear before you today in my capacity as Chair of the Institute of Medicine—now the National Academy of Medicine—Committee on Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights, which issued its report in April 2014, as Representative Edwards has already noted.

In addition, I should note that I'm currently Chair of the Board on Health Sciences Policy for the Health and Medicine Division of the National Academies, and a member of the Division's standing Committee on Aerospace Medicine and Medicine of Extreme Environments.

In those contexts, I will describe recommendations contained in the report of the committee I mentioned related to protecting and sustaining astronaut health.

First, I want to say that my committee's report in 2014 was not the first to identify the ethical obligations to protect astronaut health, as has been noted by others. As outlined in the 2001 IOM report titled *Safe Passage*, and as noted in the my committee's report as well, the new challenges that will be faced in long-duration and exploration spaceflight necessitate a new look at the ethics principles for these missions, and I quote now from *Safe Passage*: "Current ethical standards for clinical research and practice with astronauts were developed in an era of short space missions when repeat missions were the norm and a return to Earth within days was possible. In future missions beyond Earth orbit, however, a diverse group of astronauts will travel to unexplored destinations for prolonged periods of time. Contact with Earth will be delayed, and a rapid return will be impossible. Long-duration missions beyond Earth orbit, space colony habitation, or interplanetary travel will create special circumstances for which ethical standards developed for terrestrial medical care and research may be inadequate for astronauts. These ethical standards may require reevaluation." That again is from 2001.

My committee in 2014 noted that NASA, as an employer, a federal agency responsible for innovation and exploration, a research

sponsor, and an international partner, has moral obligations to formally recognize and act on responsibilities that logically flow from the ethics principles outlined in our report if long-duration and exploration spaceflights are to be ethically acceptable. Among the six principles we identified, two are particularly relevant for discussion in the context of health care for former astronauts. Those principles are (1) fairness, and (2) as already noted by Representative Edwards, fidelity. Let me quote from the report. “Fairness is the principle that requires that equals be treated equally, that burdens and benefits be distributed fairly, and that fair processes be created and followed. NASA’s decision making surrounding missions should explicitly address fairness, including the distribution of the risks and benefits of the mission, crew selection, and protections for astronauts after missions.”

An important ethical challenge of exposing humans to the risks of long-duration and exploration spaceflight is that the burden of the health risks associated with these missions falls to a limited number of astronauts and their families as well while the benefits of the proposed missions accrue primarily to future astronauts and to society more broadly.

In addition to being a concern of appropriate risk-benefit balance about going at all, the appropriate risk-benefit distribution must also be considered. Asking individuals to accept great risk, either in likelihood or magnitude of the harm to be caused, can be partially balanced by making a commitment to provide long-term health care and health monitoring.

The second principle we identified is fidelity, and again I quote from the report. “Fidelity is the principle that recognizes that individual sacrifices made for the benefit of society may give rise to societal duties in return. Given the risks that astronauts accept in participating in hazardous missions, NASA should respect the mutuality of obligations and ensure health care and protection for astronauts not only during the mission but after they return, including provision of lifetime health care for astronauts.”

Those who consent to incur long-term health risks for society’s benefit are entitled to fidelity, reflected in society’s commitment to minimize any harms that emerge, whenever they emerge. The committee noted that this concept of fidelity or reciprocity resonates with the basic, widely shared understanding that it is unjust to allow some people alone to bear burdens which, in all fairness and justice, should be borne by the public as a whole. As a practical matter, the public cannot physically share the risks that astronauts will bear. It can, however, share the costs and burdens of ongoing risk mitigation efforts.

An astronaut’s consent becomes binding and irrevocable at the moment the mission launches. Astronauts are free to withdraw their agreement to participate prior to launch of course, but from the launch moment forward, it becomes nearly impossible to turn back, and astronauts likely will encounter uncertain and unquantifiable risk exposures and endure potential harms to health that will persist after the mission. The irrevocability of participation in spaceflight creates an ethical imperative to define long-term duties owed to the participating astronaut.

In this context, the principles identified by our committee report support the minimization of risk of harm, the treatment of injuries or health conditions during the flight, and the ongoing monitoring and provision of health care after the flight. This binding duty to provide ongoing surveillance, monitoring, and health care during the lifetime of the astronaut is part of the continuum of risk management that begins with engineering and design efforts to minimize risk and continues through the flight and post flight. Our committee concluded that the ethics responsibilities that result from sanctioning high-risk activities include continuous learning and engagement in health-related activities that protect astronaut health, support ongoing evaluation of health standards, improve mission safety, and reduce risks for current and future astronauts.

Employers that knowingly expose employees to risks have an ethical responsibility to provide protection to the extent possible and to address the harms that occur when protections fail or turns out to be inadequate. Robust research and health monitoring or surveillance programs that fully inform all who are involved, including astronauts and their families, are required.

Furthermore, the committee maintained that the nation, through NASA, has the ethical duties to protect and sustain astronaut health based on the ethics principles of fairness and fidelity. Providing lifetime health care to astronauts respects the commitment that our astronauts have made and the risks they have taken on society's behalf.

Thank you.

[The prepared statement of Mr. Kahn follows:]

Summary Testimony for
the
United States House of Representatives Committee on Science, Space, and
Technology
for Hearing on
“Human Spaceflight Ethics and Obligations: Options for Monitoring,
Diagnosing, and Treating Former Astronauts”

June 15, 2016

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Chairman Babin and Ranking Member Edwards, thank you for the opportunity to submit testimony on this timely and vitally important subject.

I am a Professor of Bioethics and Public Policy at the Johns Hopkins Berman Institute of Bioethics in Baltimore. I appear before you today in my capacity as chair of the Institute of Medicine (now National Academy of Medicine) Committee on Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights, which issued its report in April 2014. In addition, I also currently am chair of the Board on Health Sciences Policy for the Health and Medicine Division of the National Academies of Science, Engineering, and Medicine, and a member of the Division’s standing Committee on Aerospace Medicine and Medicine of Extreme Environments.

In those contexts, I will describe recommendations contained in the report of the Committee on Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights (Ethics Committee) related to protecting and sustaining astronaut health. [<http://www.nap.edu/catalog/18576/health-standards-for-long-duration-and-exploration-spaceflight-ethics-principles>]

As outlined in the 2001 Institute of Medicine report *Safe Passage*, and as noted in the Ethics Committee’s report, the new challenges that will be faced in long duration and exploration spaceflight necessitate a relook at the ethics principles for these missions:

“Current ethical standards for clinical research and practice with astronauts were developed in an era of short space missions when repeat missions were the norm and a return to Earth within days was possible. In future missions beyond Earth orbit, however, a diverse group of astronauts will travel to unexplored destinations for prolonged periods of time. Contact with Earth will be delayed, and a rapid return will be impossible. Long-duration missions beyond Earth orbit, space colony habitation, or interplanetary travel will create special circumstances for which ethical standards developed for terrestrial medical care and research may be inadequate for astronauts. These ethical standards may require reevaluation.” (*Safe Passage*, 2001, p. 173)

Our committee noted that NASA, as an employer, a federal agency responsible for innovation and exploration, a research sponsor, and an international partner, has moral obligations to formally recognize and act on responsibilities that logically flow from the ethics principles outlined in our report if long duration and exploration spaceflights are to be acceptable. Among the six principles identified by the committee, two are particularly relevant for discussion in the context of health care for former astronauts. Those principles are (1) fairness, and (2) fidelity.

“Fairness—the principle requires that equals be treated equally, that burdens and benefits be distributed fairly, and that fair processes be created and followed. NASA’s decision making surrounding missions should explicitly address fairness, including the distribution of the risks and benefits of the mission, crew selection, and protections for astronauts after missions.” [Ethics Committee report, p. 128]

An important ethical challenge of exposing humans to the risks of long duration and exploration spaceflight is that the burden of the health risks associated with these missions falls to a limited number of astronauts and their families while the benefits of the proposed missions accrue primarily to future astronauts and to society more broadly. In addition to being a concern of appropriate risk-benefit *balance*, the appropriate risk-benefit *distribution* must also be considered. Asking individuals to accept great risk (either in likelihood or magnitude of harm) can be partially balanced by making a commitment to provide long-term health care and health monitoring.

“Fidelity—the principle recognizes that individual sacrifices made for the benefit of society may give rise to societal duties in return. Given the risks that astronauts accept in participating in hazardous missions, NASA should respect the mutuality of obligations and ensure health care and protection for astronauts not only during the

mission but after return, including provision of lifetime health care for astronauts.”
[Ethics Committee report, p. 128]

Those who consent to incur long-term health risks for society’s benefit are entitled to fidelity, reflected in society’s commitment to minimize any harms that emerge, whenever they emerge. The committee noted that “this concept of fidelity or reciprocity resonates with the basic, widely shared understanding that it is unjust to allow “some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.”” [Armstrong v. United States, 364 U.S. 40, 49 (1960)] As a practical matter, the public cannot physically share the risks that astronauts will bear. It can, however, share the costs and burdens of ongoing risk-mitigation efforts.

An astronaut’s consent becomes binding and irrevocable at the moment the mission launches. Astronauts are free to withdraw their agreement to participate prior to launch of course, but from the launch moment forward, it becomes nearly impossible to turn back, and astronauts likely will encounter uncertain and unquantifiable risk exposures and endure potential harms to health that will persist after the mission.

The irrevocability of participation in spaceflight creates an ethical imperative to define long-term duties owed to the participating astronaut. In this context the principles identified by our committee support the minimization of risk of harm, the treatment of injuries or health conditions during the flight, and the ongoing monitoring and provision of health care after the flight. This binding duty to provide ongoing surveillance, monitoring, and health care during the lifetime of the astronaut is part of the continuum of risk management that begins with engineering and design efforts to minimize risk and continues through the flight and postflight.

Our committee concluded that the ethics responsibilities that result from sanctioning high-risk activities include continuous learning and engagement in health-related activities that protect astronaut health, support ongoing evaluation of health standards, improve mission safety, and reduce risks for current and future astronauts.

Employers that knowingly expose employees to risks have an ethical responsibility to provide protection to the extent possible and to address the harms that occur when protection fails or turns out to be inadequate. Robust research and health-monitoring or surveillance programs that fully inform all who are involved, including astronauts and their families, are required. Furthermore, the committee maintained that the

nation, through NASA, has the ethical duties to protect and sustain astronauts' health based on the ethics principles of fairness and fidelity. Providing lifetime health care to astronauts respects the commitment that astronauts have made and the risks they have taken on society's behalf.

Thank you.

Jeffrey Kahn is the Robert Henry Levi and Ryda Hecht Levi Professor of Bioethics and Public Policy in the Johns Hopkins Berman Institute of Bioethics. He is also Professor in the Department of Health Policy and Management in the Johns Hopkins University Bloomberg School of Public Health. Prior to joining the faculty at Johns Hopkins, Prof. Kahn was Director and Maas Family Endowed Chair in Bioethics in the University of Minnesota Center for Bioethics. His research interests include the ethics of research, ethics and public health, and ethics and emerging biomedical technologies; he speaks widely both in the U.S. and abroad, and has published four books and over 125 articles in the bioethics and medical literature. He is an elected Fellow of the Hastings Center, and has chaired or served on committees and panels for the National Institutes of Health, the Centers for Disease Control, and the Institute of Medicine.

Chairman BABIN. Thank you, Dr. Kahn. All fascinating testimony. I thank every one of you witnesses for your testimony, and now I recognize myself for five minutes for questions.

The first one I'd like to direct to Dr. Williams. How would additional authority affect existing rights and benefits under current statutes? And would creating a new program at NASA impact the standards that are set forth by the Departments of Labor and Veterans Affairs for compensation and treatment? In other words, will a new authority make it easier or harder for astronauts to receive the treatment and compensation that they are due?

Dr. WILLIAMS. Thank you for the question, sir. I don't think that there'll be a major impact to existing infrastructure. As a matter of fact, we envision using an existing claims infrastructure working very closely with our partners in the Department of Labor, and we're developing the same relationships with the Department of Veterans Affairs to approach this as a facilitated claims process, providing the expertise and space medicine and disease-specific experts as well as the evidence base that we've accrued so far to help determine the likelihood of association with occupational exposure as disease develops in our former and retired astronauts.

With regard to your question about whether I think this will make it easier to advance the plausibility of association, I think it likely will, sir. I think endorsement by the Congress in recognition that these unusual exposures can cause disease in our astronauts, I think that will send a powerful message and will enable us to be more successful in taking care of them.

Chairman BABIN. Absolutely. Thank you very much, Doctor.

The next question I'd like to direct to our three distinguished astronauts. If NASA is given authority to provide additional treatment for astronauts beyond existing programs at the Department of Labor and Department of Veterans Affairs, should NASA provide that treatment in-house at NASA or reimburse patients for private-sector treatment? Captain Cassidy, how about you first?

Captain CASSIDY. Mr. Chairman, that's an excellent question. I think that there's some degree of care that can be handled in-house at the Johnson Space Center but I also think that there should be some flexibility in order to take care of the former astronauts who potentially in their older age have a hard time getting back to Johnson Space Center, or because of their condition can't make that trip.

Chairman BABIN. Right. Okay.

Captain Kelly?

Captain KELLY. Sir, I don't really have anything to add other than what Chris said, but I think, you know, the emphasis on some of these guys, as we age and traveling back and forth to Houston could be problematic.

Chairman BABIN. Sure. Thank you.

And Captain Lopez-Alegria?

Captain LOPEZ-ALEGRIA. Yes, Mr. Chairman, pretty similar. I think clearly there are some things that the clinic at Johnson Space Center could not do from a medical perspective. We couldn't, you know, treat somebody with chemotherapy, for instance, at JSC, but I think to the extent possible, we should try to keep it in-house just to facilitate the transfer of the data, which are very important

to the discussion, but agree with my colleagues about that being impractical in some cases. I think that we should endeavor to make it happen when possible but realize that that won't always be the case.

Chairman BABIN. Sure, and then just to follow up, if NASA does decide to diagnose and treat conditions in-house, does this pose a potential conflict of interest when NASA is financially obligated to compensate former astronauts for conditions caused by their federal service? If one of you three would like to take a stab at that?

Captain CASSIDY. Well, let me start by saying—and Scott will back me up on this—as military aviators, we have an adversarial relationship with our flight surgeons generally. I was expecting that to be the case at NASA and could not have been more wrong about that. The relationship that we enjoy is very unique, and there's no doubt in my mind that our best interests are at heart when they give us treatment. So I would have a great level of confidence that the people with whom we all have personal relationships would be very disposed to help us to the extent possible, and I don't see there being a conflict of interest. I think that if you're saying the conflict of interest would mean they would be reluctant, I don't see that as a likelihood.

Chairman BABIN. Right. Anybody else? Pretty much in agreement?

It's an interesting comment you make, because I was an Air Force dentist, and occasionally we had to put DNIF on somebody's records, and they were not happy: duty not to include flying.

Let's see. I think I'm out of time so I will yield back, and we will call on the next one, the Ranking Member from Maryland, Ms. Edwards.

Ms. EDWARDS. Thank you, Mr. Chairman, and thank you again to the witnesses. Your testimony was really—was very thorough.

One of the questions that I had as we came up, and particularly for Captain Lopez-Alegria, if you could tell me whether the care is provided in-house or out-of-house in terms of the surveillance data that are gathered, and Dr. Williams, please contribute as well, it seems to me that you all are already close to or you already have a tool that could—a screening tool that could easily be used more broadly, whether that's at Johnson or at some private care facility, and the question is whether we can authorize both the mechanism for surveillance but also separately the provision of health care, in which case you would be able to capture more than the 60 percent, I think, of the Astronaut Corps, retired and active, who are currently participating. Would that be right?

Captain LOPEZ-ALEGRIA. Well, I think your last point would absolutely be right, that you would have far more participation than we have. I don't know enough about what the current limits of the authority on the screening that are in place right now, but I do know that some of the tests that I mentioned in my oral testimony, which could be done, which have very specifically targeted to hazards that are known to be caused by flying in space, are not being done, and I think that if that authority does not exist, which I assume it doesn't, who would be doing them, then they should be.

Ms. EDWARDS. Dr. Williams?

Dr. WILLIAMS. Yes, ma'am. We—our current authority to provide that ongoing health monitoring to former and retired astronauts is limited. Our ability to spend appropriated funds in providing that diagnosis and much more so in providing treatment in that group, we don't feel like we have the authority to do that. So although we have the basic framework in place, which is the Lifetime Surveillance of Astronaut Health, we believe that that framework can be greatly enhanced and greatly expanded and become much more comprehensive with specific authority to provide diagnosis and treatment.

Similarly, we think that our ability to engage and treat serious illness that arises in the Astronaut Corps will be greatly facilitated by the—for the lack of a better word, I'd say the facilitated claims process we envision with our partnerships with the Department of Veteran Affairs and the Department of Labor.

Ms. EDWARDS. So, I mean, I want to get to this, because I think there's a separate question. If we give the authority that then allows for the provision of health care, we could do that either through those who are covered by VA, those who are covered under the FECA, or other kinds of private health care. The question then becomes, can we develop a tool that encompasses all of the kind of surveillance that you would need both to provide current health care but also to look down the line in terms of providing prevention or looking forward to the future Astronaut Corps, and you're saying that we would need—you would require a separate legislative authority in order to be able to do that?

Dr. WILLIAMS. Yes, ma'am. I think based on the very small number of cadre of the astronauts and the very unique exposures and the need for targeted surveillance and broad preventive surveillance in this group targeted toward those exposures that we know more about than anyone else on the planet, I think that NASA having that care—we do have within our agency a comprehensive healthcare delivery system that is aimed at the active Astronaut Corps, and leveraging our abilities along those lines on behalf of the retired and former astronauts including helping coordinate their care wherever they live I think would go a great way toward making sure that we take care of them and recovering as much data as possible to establish our evidence base.

Ms. EDWARDS. And Captain Cassidy, I take it that you believe that we—that Congress has to provide a broader legislative authority to provide those services?

Captain CASSIDY. Yes, ma'am. I think that it's—my experience base is with the active astronauts, and like my two colleagues here, I don't have a whole lot of experience with what it's like as a former astronaut to go through that. I've talked to both of them, but where I think we can do—I know we can do a better job at pulling this data together, and the execution of how we do that, where it happens, what tests are done, and the mechanism for payment I think are things that can be further honed and discussed as we move forward and actually get this going, but those are things that I think we could collectively get a better story on.

Ms. EDWARDS. And Dr. Kahn, can you tell me, is there any other sector that you can think of where there's an employer who has an employee who engages in risk for the purposes of completing their

employment where there isn't a comparative ethical obligation for care?

Mr. KAHN. Thank you, Representative Edwards. It's a really interesting question. In fact, part of the work of the committee that I had the privilege to chair, we tried to find parallel occupational examples, and in fact, it's quite unique is the short answer. And so when people leave occupational environment, they tend to have either a new job or they become retired and then they're covered by other means. So astronauts are really frankly in a unique category that way.

Chairman BABIN. Thank you, Ms. Edwards.

I now call on the gentleman from Alabama, Mr. Brooks.

Mr. BROOKS. Thank you, Mr. Chairman.

Captain Kelly, thank you, sir, for being here today and for your service to America's space program. As many are aware, you and your twin brother, Mark Kelly, are providing scientists with a wealth of information on the effect that human spaceflight has on the body. NASA is set to share the results of the study next year. Are you in a position where you can give us any previews of what they're finding so far by sharing with us the most surprising or interesting things that you have noticed so far?

Captain KELLY. Well, I mentioned in my testimony the difference between my initial 159-day flight and 340, my symptoms immediately upon return. I have gotten some data back, my bone mass, muscle mass data, some of the data on my vision, that for me I was kind of surprised that it was relatively flat in comparison to the 159 days. In other words, being in space for twice as long didn't mean that I lost twice as much bone mass. It was pretty similar. So I think some of these we do have, a good understanding to how to mitigate the risks to bone and muscle loss so we can stay in space longer.

The data with regards to my brother and the comparison with me, a lot of those samples just came back on SpaceX, my biological samples, so, you know, like most research, you collect the data, you analyze the data, you write the reports, have it peer-reviewed. I think that type of genetic data, the effects of the radiation environment, the effects on my immune system, things like that as it compares to my brother are just going to take much longer.

But I was actually, you know, pleasantly surprised that my bone and muscle data was pretty much flat between the two flights, although, you know, how I felt when I got back was much different.

Mr. BROOKS. And this is a question for each of you, though I'd like to start with the astronauts, Captain Cassidy first and working our way around, and then on the two ends of the table, and whoever wants to follow them, feel free.

With current technology, can NASA safely send an astronaut on a Mars mission without resulting significant adverse health risk, and if not, what should be done to safely protect astronauts on a Mars mission?

Captain CASSIDY. Sir, that's a fantastic question because that's where I think our nation should go, to Mars, and that's where our vision is, and so how do we do that effectively and safely is a fantastic thing to consider, and clearly, radiation monitoring and protection is critically important there. Do I think that we could do

that mission safely right now? We could do it as safely as we think we can, and there are certain risks that we don't know, and that's where collecting this data between now and going to Mars will keep my future colleagues safer.

Mr. BROOKS. Captain Kelly?

Captain KELLY. Yes, sir. You know, my time on the Space Station, I was really inspired that building and operating this vehicle was the most difficult thing we have ever done, and I think it's proven that if we decide to do something and we set our mind to it and put the resources behind it, we can be successful, whether that's going to Mars or curing cancer if we decide that that's what we're going to do, and we devote the appropriate resources to do it, we can do it.

Now, there are challenges with going to Mars. Chris mentioned radiation, which I completely agree with. I think the physical challenges, that would be the number one concern I would have is protecting the crew members on that long trip away from the protection of Earth. I think there are also, you know, challenges in the systems that keep us alive onboard the Space Station. You know, these are designed to work for long periods of time in low-Earth orbit but having them that can, you know, operate consistently, reliably, get us to Mars and back, is a challenge, but I think it's clearly a challenge that if we decide that's what we want to do, then we can accomplish it.

Mr. BROOKS. Well, with respect to the number one concern that both of you have mentioned, radiation, do we have the technology now to protect our astronauts from the radiation of a long-term flight to Mars and back or do we need to develop new technology?

Captain KELLY. You know, I think there's two ways to approach that. One is, you get there really fast so you're not exposed to the radiation environment for as long, and the other one is some means of, you know, insulating the crew members from it, and you know, I'm not an expert on this, but my understanding is, if you have a propulsion system that potentially has a magnetic field as part of it, that can act like the magnetic field of the Earth to protect us from certain types of radiation, but again, I'm not an expert in this area.

Mr. BROOKS. Captain Lopez-Alegria?

Captain LOPEZ-ALEGRIA. Thank you, Representative Brooks. You know, I think could we do it technically, technologically? Perhaps. It would be incredibly expensive the things that you mentioned and my colleagues have mentioned about radiation. You could shield. That takes mass. That makes the vehicle heavier. That makes the vehicle more expensive. The current propulsion technology, we've heard how long it would take the mission. We'd have to bring our food with us. There are so many things that it's possible to do. I think a breakthrough in technology would make a lot of those problems go away or at least become much more easy to solve.

One thing that I do think is going to happen in almost any case, it's going to be very difficult to have any kind of a reasonable abort possibility once you're on your way, and so this country's going to have to have a different risk acceptance posture, not just for radiation exposure, which is right now three percent above the normal population is what we admit for a risk of exposure-induced death,

that would probably have to change. But also just the notion that somebody could have an unforeseen medical problem on the way which today we could have the crew member on the ground in a matter of hours, it would take potentially months to get them back.

So we could do it. I think we have to go through some evolutionary processes in the way we think both at NASA and as a country for it to happen.

Mr. BROOKS. Well, my time is expired, but if the Chair would permit for Dr. Kahn and Dr. Williams to answer, that'd be great, but if not—

Chairman BABIN. No, certainly, go ahead, if you have something to add to that.

Mr. BROOKS. Dr. Kahn or Dr. Williams, would either of you like to add anything to a Mars mission safety, technological advances we might need to ensure health safety.

Dr. WILLIAMS. I think my colleagues covered it quite well. Physiologically, we believe that we could send people on a Mars-duration mission out and back, you know, all the other safety concerns notwithstanding. We believe we could do that. Physiologically, I think it's safe to say that those astronauts would be forever changed. In all likelihood, they'd have a greater risk of developing a fatal cancer during their lifetime and the associated changes in bone and muscle. I mean, they may have a greater fracture risk and the cataracts and all the things we've talked about.

One of the great challenges are the unknowns, and there are unknowns and unknown unknowns with regard to the increased duration of spaceflight. So that's what makes it so imperative for us to continue our studies and to continue gathering as much data as we possibly can in support of an eventual Mars mission.

Mr. BROOKS. Dr. Kahn, do you have anything to add?

Mr. KAHN. I would just add to what Dr. Williams just had to say, that the committee that I chaired actually understood that there were such great unknowns and unquantifiable risks, and rather than try to answer the question that you posed about what technological breakthroughs would be necessary, whether we could do it today, we gave them a framework to think about the ethics of exceeding existing standards and how to think about that since, as Captain Lopez-Alegria said, there are existing health standards and we have to evaluate those standards in light of the mission that is being proposed, and that's what the committee that I chaired had to say.

Mr. BROOKS. Mr. Chairman, thank you for your indulgence.

Chairman BABIN. Yes, sir. Thank you.

I'd like to now call on the gentleman from Virginia, Mr. Beyer.

Mr. BEYER. Thank you, Mr. Chairman. I thank all of you very much for being here.

Dr. Kahn, given the difficulty of establishing causality for medical conditions that may have resulted from human spaceflight one of the options would be to have NASA take care of all the medical problems that astronauts would have in the years to come. What are the pros and cons of such an approach?

Mr. KAHN. Thank you, Representative Beyer, for that question. I think that's actually a really important question, and I'll speak to it from the ethics perspective because that's what I know, and

in fact, the committee that I chaired discussed that, and we came to the conclusion that the causality question is impossible to answer, and that we as a country and a society owe astronauts protection and provision of care throughout their lifetimes without asking the question about whether—what they might suffer from in terms of injury or health needs was a result of their time in space or not.

Mr. BEYER. Thank you, Dr. Kahn.

I met earlier today with the Fire Chief for the County of Arlington in Virginia and talked specifically about this issue with the presumption of heart-lung disease, the presumption that if they got heart disease or lung disease later, that it was presumed to be from rushing into burning buildings, and he said it actually expanded in Virginia over the law to things to do with the GI tract also. So this just extends it to all those who go into space for us.

Mr. KAHN. And as you heard from others, there's new information coming out all the time, and so what we don't know today may be something we learn about in the future, and so the committee that I chaired really did not find the causation question a compelling one as a matter of limitation of provision of the—of lifetime healthcare benefits.

Mr. BEYER. I am struck today by the two big reasons we have at this hearing. On the one hand is the ethical considerations, the responsibility to take care of people who are sacrificing for all humankind. On the other hand, there's the simple practical data reason that we want to learn as much as we can to be able to move forward.

Dr. Williams, what about when Captain Kelly retires and goes to work for a private space person, you know, SpaceX or Orbital, how does that influence the government's responsibility to take care of him and his space things, the space-related conditions for years to come?

Dr. WILLIAMS. Yes, sir, another great question. I think there's plenty of precedent in the U.S. government that we would consider that to have no impact at all on our ethical obligation to take care of Captain Kelly and on our desire to gather as much data as we can to inform our database and to help us protect crews in the future, so I think there's no accrual, no effect at all, sir.

Mr. BEYER. I was very impressed, fascinated by reading, Captain Kelly, all the impacts of your 340 days in space, everything from the rash to the flu-like symptoms and all the things we don't know yet, the unknown unknowns.

So Dr. Kahn, from an ethical standpoint, especially after the recent death of Muhammad Ali, I mean, my mother never wanted me to box, right? The concussion and what the NFL is trying to deal with, concussions right now we see, those are voluntary sports. At what point do the ethical considerations become so great that we become reluctant to send men and women into space for the long voyages?

Mr. KAHN. At what point would they? Is that the—is that your question?

Mr. BEYER. You know, we send young men and women to go fight for us overseas because they're defending the country and we know we're going to lose some. We don't ever want to lose anybody

despite Elon Musk saying the other day, “We’re going to go to Mars and some people are going to die.” Do we go into this knowing with certainty that some of these health effects, the long-term health effects, are going to be inevitable?

Mr. KAHN. I think what we want to be sure of, as sure as we can be, that we can protect the men and women who go into long-duration spaceflight to the greatest extent possible, and that we learn along the way, so among the things that hasn’t come out yet today is this notion of long duration, so we’re talking hundreds of days in transit until there’s some new propulsion system, and so we can learn along the way. So data will come back to Earth from the experience of astronauts as they fly, and we should use that and learn and use that to decide about whether people should spend more time in protective cocoons in the—on the way or whether there should be some other means by which we should modify exposure along the way. So I think it’s a notion of learning as we go but we don’t go until we’re sufficiently confident that it’s safe enough, and then it’s up to NASA to decide when and if it’s safe enough.

Mr. BEYER. Thank you very much.

Mr. Chairman, I yield back.

Chairman BABIN. Yes, sir, thank you, and I’d like to recognize the gentleman from Colorado, Mr. Perlmutter.

Mr. PERLMUTTER. Thank you, Mr. Chairman, and thank you for having this hearing. It’s fascinating and it’s important. Gentlemen, thank you for your service.

Dr. Kahn, I want to start with you because I thought your two sort of pillars of fidelity and fairness really kind of lay out the thinking on this for me.

You know, if somebody—these three gentlemen next to you are explorers and they put themselves at risk to explore in the name of the United States, in the name of science, in the name of adventure, in the name of I don’t know what, lots of things, and they now have put themselves at risk. So it’s my opinion, based on your two principles of fidelity and fairness, that we have a responsibility to provide both the medical care that they may need on into the future and the research that they provide us as to their health.

So did your committee agree with you on this fidelity and fairness? It certainly resonates with me.

Mr. KAHN. Yes. Sorry if I wasn’t clear, Representative Perlmutter. The—my testimony represents the conclusions of the committee that I chaired, and everything I said actually is a summary of what’s in our report, which was issued in 2014, and so that was the consensus of those 16 people who have a variety of expertise, some like mine but actually two former astronauts were members of this committee, along with scientists and physicians and occupational health specialists.

Mr. PERLMUTTER. The reason I’m sort of thinking about this, and Dr. Williams, you can chime in if you choose, you know, in my district we have Rocky Flats, where we built the nuclear triggers for our bombs, and we had a lot of workers out there. They’ve developed a number of maladies as a result, some I guess anticipated some not anticipated, and we came up with a—we the Congress—came up with the Energy Employees Occupational Illness Com-

pensation Program, which has worked in some regards and hasn't worked very well in other regards because, you know, whether it's bone mass or some issue of radiation or something like cataracts, completely unexpected, we've seen maladies that were never expected. So in your analysis, Dr. Williams or Dr. Kahn, how do we be inclusive? Do we just—see, right now, the burden is on the worker to say that the illness came from working at Rocky Flats. I'd just like to say hey, if you worked at Rocky Flats and you're sick, we're going to take care of you. If you're an astronaut and you got up there, we're going to take care of you. But it gets expensive. We've got to be prepared for potential costs if we build our astronaut base. I mean, what was your committee considering? And Dr. Williams, have we estimated what costs we might see in the future?

Mr. KAHN. So the committee that I chaired did not—was not asked and did not try to estimate the cost, so we identified what we thought were, as you articulated, the pillars—we called them principles of ethics that would support recommendations which included a recommendation for lifetime provision of health care for astronauts but we did not go past that into the practical question of how much it would cost for how many people or for how many years we're discussing.

Mr. PERLMUTTER. Dr. Williams?

Dr. WILLIAMS. Yes, sir. I think when you articulated the sentiment that if we send you in harm's way as astronauts, we want to take care of you, I think that's what NASA absolutely wants to do.

The practicalities of doing that with this legislation, we can—we have to be aware of the problems, hopefully at the earliest stage possible in order to remediate them, and that's the monitoring portion of our—the health monitoring portion of our proposal, which is quite detailed and quite targeted and broadly preventive in nature. And then I think with this authority, work very closely—under the envision model, work very closely with folks in existing claims structures—the DOL and the VA, whoever we need to—to lean very forward and be very proactive in—with regard to working—providing evidence and best expert opinion to try to receive favorable consideration of claims and acceptance of diseases as they arise.

Mr. PERLMUTTER. Well, for all of us on this Committee, you know, I think I showed you, Captain Kelly, when you were up on Space Station, you know, 2033 we can do this. I mean, we really want—I don't know, you know, exactly what the timing is going to be. That'll be for the technicians and the engineers and you astronauts and the scientists to figure it out, but we want to get there, but we want you not to put your lives at stake. I mean, there will be some level of risk. I know I as a Member of Congress on behalf of the 750,000 people that I represent want to make sure that when you do put your lives at risk that—and your health for who knows how long down the road, we as the United States of America help you with your health care. Hopefully there's no problems, but if there are, we help you.

And so I just thank you for your service, gentlemen. Docs, thank you for looking at this. This is important stuff. Thank you.

Chairman BABIN. Thank you. Thank you very much. Thank you, Mr. Perlmutter.

I think there's a little time left if we could go back through for another round of questioning if the witnesses are agreeable and the members. Why don't we this? Instead of 5 minutes, we'll have a 2-minute question period, okay? And Mr. Perlmutter, we're going to keep you at 30 seconds.

Okay. I'm going to start out with Dr. Williams. Similar to the question that Mr. Perlmutter asked, NASA has indicated that extending existing monitoring of former astronauts would increase the cost to NASA from approximately \$400,000 a year to around \$800,000 a year. A recent University of Nebraska Medical Center report indicated that providing medical care for all 367 astronauts and their families would cost between \$2.4 and \$6.5 million a year. How much money would NASA's current proposal cost per year? Do you know that?

Dr. WILLIAMS. We think the direct portion, health monitoring portion, would be in the neighborhood of doubling our current cost to \$800,000 a year. Right now, we spend 400 a year for that portion. We believe if we—including remediating providers in the community for testing and imaging and so on and so forth, we think that would drive that cost up, and anticipating increased participation rates, we think it would drive it to \$800,000.

With regard to the remediation of illness and injury, the astronauts do display a very strong, healthy worker effect. They pursue very healthy lifestyles. They're committed during their careers and after their careers to maintaining good fitness and making good lifestyle choices. So when you compare chronic diseases and malignancies and so on and so forth to almost any comparison groups at this point, the astronauts compare very favorably. After latent period of exposure passes in the next 10 to 20 years, that's an unknown quantity at that point.

But right now, we would anticipate based on historical precedent no more than one case, maybe two cases every one or two years of significant illness that would be expensive, and by "expensive," I mean that would be in the, you know, \$500,000 range for a catastrophic case of cancer or something, and that's what we believe we would be dealing with in the short term, sir.

Chairman BABIN. And one quick question here for you, Dr. Williams, and Captain Cassidy. The Department of Labor and Department of Veterans Affairs both provide treatment for conditions derived from federal service. Are there classes of astronaut such as payload specialists who are not government employees and therefore would not be covered by existing authorities? Do you all know the answer to that?

Captain CASSIDY. Sir, currently at NASA we have active astronauts and management astronauts. Management astronauts are folks that still work at NASA but are no longer in the line for a space mission, and we used to have in the past payload specialists. We no longer have that designation. However, from our perspective, anybody that goes on a space mission on a NASA mission should be covered.

Chairman BABIN. Right. Dr. Williams?

Dr. WILLIAMS. And sir, for classes of astronauts like payload specialists, we believe that no matter what method that they use to enter the agency as a detailee or what method of employment they have, that there would be a pathway forward under existing structure to treat them just like we would any astronaut in clearly military or civilian service and pursue helping them.

Chairman BABIN. Thank you. Thank you very much.

And I now call on the gentlewoman from Maryland, Ms. Edwards.

Ms. EDWARDS. Thank you very much, Mr. Chairman, and thanks for the second round.

Dr. Williams, I want to go back to the VA system because I understand that about 60 percent of the astronauts that have flown in space are military or retired military—we have two here on this panel—and as such, any occupational injuries or conditions are currently handled by the VA. Have you actually directly addressed with the VA how occupational-related health conditions for former military astronauts as a result of spaceflight will be handled if this legislative proposal is enacted?

Dr. WILLIAMS. We have reached out to our contacts in the Veterans Administration and we are initiating discussions with them similar to those that we have initiated with the Department of Labor, and we would envision in implementation of this legislation partnerships going forward on both fronts to build this facilitated claims process with NASA playing a key role in determining accepting the diseases.

Ms. EDWARDS. I mean, it is a little bit problematic, you know, 60 percent of the astronauts are retired military, and we have—you haven't engaged the VA in this discussion before presenting legislative proposal, but I hope that that happens really soon and that you're able to share that information with us.

Captain Kelly and Captain Lopez-Alegria, you both are retired military. Have you used the existing VA system?

Captain KELLY. I think it's important—I think it's important to point out that there are—astronauts come from all different backgrounds. Some of us are retired military. I'm personally, as is Mike, covered under Tricare for life as a retired military member. If you were a member of the military and you didn't retire, I believe the VA would still cover you. There are members of the Astronaut Corps that are civil servants. Some of those civil servants retire from federal service, in which case they do have retired civil service health care, but then there are other people that may fly for one flight or more and then leave federal service without any kind of long-term health care benefits until they were potentially eligible for Medicare. So there are different categories, and I think this system, this legislation, if enacted, would benefit them and people in different ways considering the fact that, you know, we already have health care coverage that is pretty good.

Ms. EDWARDS. And in effect, at least bring the payment within one house, if not the care within one house?

Captain KELLY. Certainly, and I think that the important—the other important factor, as previously mentioned, was the fact that we can collect all this data whereas if I'm, you know, living in another state and I'm being treated under the Tricare system, NASA

doesn't directly benefit from any of that information, and also the fact that, you know, those health care providers may not even know what they should be looking for in these types of, you know, cancer or radiation-based illnesses.

You know, it's interesting, Mike and I—I was going to point this out, and I don't think he would mind mentioning it, but we're going to meet with one of our colleagues tonight who lives in the area that has recently been diagnosed with stage IV pancreatic cancer, and he's, you know, flown in space on a number of occasions, and you know, we never know whether that's actually directly related to his spaceflight but it's possible that it is.

Ms. EDWARDS. Thank you very much. I mean, a reminder, it took us 30 years after Vietnam to finally recognize the long-term impacts of Agent Orange.

Chairman BABIN. Yeah, absolutely.

The next one, Mr. Beyer, the gentleman from Virginia.

Mr. BEYER. Yes. Thank you, Mr. Chairman.

And Dr. Williams, I know you're not a statistician but I understand from reading lots of science magazines that essentially we need to get to 10,000 DNA complete disarticulations into the database before we're really going to be able to figure out what some of these DNA connections are.

You know, we have 250 retired astronauts. Sixty percent are in—so 150 are in the LSAH program right now. If we move to 80 percent, that gets us 200. What are the—what's the implications for us of the limited sample size, the limited size of the database?

Dr. WILLIAMS. It's something we've always struggled with, sir, whether we're actually doing space-based research with a small population and trying to, you know, reach conclusions or whether we're trying to do epidemiology on this very small, very uniquely exposed group of folks. The only thing—the thing I think that is most important to note is that given the group is so small, the data from every single one of them is precious and the data from every single one of them is important, and anything we can do to maximize participation in our program, both for the surveillance and recovery of healthcare data in the event of injury and illness, is critical.

Mr. BEYER. A question for any of the three captains but perhaps especially for Captain Kelly. We had a Mars hearing here a couple weeks ago, and with, you know, the big companies that are developing all the places to get there, and Andy Weir came, who wrote *The Martian*, and at the end he threw out the proposal that we should be thinking about using rotational energy to create artificial gravity on the way up. So how much of the consequences that you all have felt have been radiation related versus gravity-free-related, and I say that because I think for Ed and for me, the highlight of this Committee so far has been when you and Dr. Lindgren did your flips at the end of the flight.

Captain KELLY. Well, you know, I believe all the symptoms that we have, the stuff that we can feel when we get back, is a result of the microgravity environment versus radiation. I think the radiation effects are, you know, more long term and unknown, you know, of someone that does develop a cancer, whether or not that was due to the radiation, I don't think we can ever say for sure be-

cause it may have—you know, we get radiation here on Earth as well. It just increases our risk of those type of cancers.

So as far as, you know, having an artificial gravity to mitigate those risks, I think, you know, based on how I felt after being in space for a year, if I was going to travel to Europa, for instance, and it's going to take, you know, many, many years to get there, I think—and then you have to perform after being in space for multiple years and you had to perform away from Earth, I think that type of artificial gravity would be crucial. If we're going to fly around the Moon or fly around Mars, for instance, and it's going to take, you know, three years and you'd be in space for three years or if you're going to land and be on the surface for a few weeks, being in space for an extended period of time is going to have a negative effect but fortunately you're coming back to Earth where, you know, there's a big, you know, system to support you. So artificial gravity in that type of mission I think is less critical.

Mr. BEYER. Great. Thank you very much.

Mr. Chair, I yield back.

Chairman BABIN. Yes, sir. Thank you, Mr. Beyer.

And now for the gentleman from Colorado, Mr. Perlmutter.

Mr. PERLMUTTER. For my 30 seconds.

Chairman BABIN. No, we'll give you two.

Mr. PERLMUTTER. So this is to all of you. So as things have developed and we've heard from Mr. Musk and SpaceX that, you know, their intentions to try to get astronauts to Mars in the 2020 time frame or sometime, and we know that there's going to be more commercial endeavors in space. So we have a small pool to do research on. Should we consider those astronauts that are on a private capsule? Should they be covered by something like this? And I'll start with the three captains and then go to the ethicist, I guess.

Captain LOPEZ-ALEGRIA. Well, I've been in this room a lot wearing my hat as president of a commercial spaceflight federation, so your comments about democratization of access to space are near and dear to my heart. I think that we would love to have the data from those folks that are going to be going, you know, first on sub-orbital but at some point on orbital flights. I do not think it is the responsibility ethically but I will leave that to the ethicist, but it seems to me that it would have to be a voluntary program for them, but what is clear is that the data that we are gathering in LSAH and hopefully with this expanded authority, our flights and our careers have been paid for by taxpayer dollars and we owe those taxpayers those data to help them make informed decisions about spaceflight.

Captain KELLY. I don't really have anything to add other than what Mike said. I think that makes a lot of sense.

Captain CASSIDY. And sir, I concur as well.

Mr. PERLMUTTER. Okay. So to the doctors, do you want to have a bigger pool? Do you want them in there, or should we cover them? What do you think?

Mr. KAHN. Well, so I'll start. I think in terms of coverage that if it's commercial spaceflight, then those companies ought to take on that obligation, so I do think there's an obligation but not on

the part of the government to protect those people but on the part of Elon Musk or whomever.

In terms of the data, that to me is something that ought to be encouraged but I think it's hard to obligate on the part of individuals. So, you know, I think as our astronaut colleagues here will say, there's very few of them, and every bit of the data that is precious, and with the proper protections, there should be, I think, a lot of willingness to participate, but I don't think you can force people to do that.

Dr. WILLIAMS. And sir, I think our database and our experience base would form the risk assessment database that the commercial companies are going to have to use. That's going to inform their risk decisions when it comes to a health standpoint and undertaking some of these longer missions.

I agree with my colleagues. From a practical perspective, our health care infrastructure, and I'm sure our research community too would pursue helping them as much as we could by sharing our experience and our data as much as we can, and also we would seek to facilitate their gathering of data. We have a lot of experience in doing that. And if there were opportunities to leverage their data on behalf of future human spaceflight, we would welcome the opportunity to do so.

Mr. PERLMUTTER. Thank you very much.

Thanks, Mr. Chairman. I yield back.

Chairman BABIN. Yes, sir. Thank you, Mr. Perlmutter.

I want to thank the witnesses. It's been an extremely edifying hearing, and to be honored with the three astronauts and the two doctors, thank you all for your many years of service to your country, and really I want to thank you from the bottom of my heart.

The record will remain open for two weeks for additional written comments and written questions from the Members.

So without any further ado, this hearing is adjourned.

[Whereupon, at 4:27 p.m., the Subcommittee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

*Responses by Dr. Richard Williams***HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE***Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing,
and Treating Former Astronauts*

Dr. Richard Williams, Chief Health and Medical Officer, NASA

Questions submitted by Rep. Brian Babin, Chairman, Subcommittee on Space

QUESTION 1:

NASA is currently authorized to provide for the monitoring, and to some degree diagnosis, of management and retired astronauts. How is the current authority to monitor management astronauts not sufficient to meet the scientific purposes of NASA's monitoring program?

ANSWER 1:

The present monitoring authority was derived from limited testing performed under NASA's *Longitudinal Study of Astronaut Health* (now known as the *Lifetime Surveillance of Astronaut Health (LSAH)*). Clear authorization would enable NASA to expand its present monitoring strategies with more comprehensive testing of former astronauts to better understand the long-term health impacts of spaceflight. Further, it would clearly enable the Agency to design and implement unique testing for suspected spaceflight-related syndromes. This proposal goes beyond monitoring and would enable the Agency to diagnose and treat such medical conditions. Results of medical monitoring, diagnosis, and treatment would be provided to NASA. Access to these records would further enable NASA to establish an evidence base to guide diagnosis and treatment for latent occupationally related conditions.

QUESTION 2:

In 2004, the National Academies' *Review of NASA's Longitudinal Study of Astronaut Health* stated that it would be difficult to discern whether or not an injury or disease exhibited later in life is actually related to spaceflight. The report cites cataracts as an example. Because of this, the report also concludes that NASA should pay for all of an astronaut's health care needs. Should we view a decision to cover all medical issues as a temporary measure? As time goes on we will understand more about the effects of space and be able to accurately determine if an issue is related to spaceflight?

ANSWER 2:

Over the years, NASA has investigated several models of healthcare delivery to address the Institute Of Medicine's (IOM) recommendations. NASA believes that linking health monitoring and healthcare to occupational paradigms is consistent with the IOM recommendations.

QUESTION 3:

NASA has told the committee that 61 percent of retired astronauts participate in the Lifetime Surveillance of Astronaut Health study. What can be done to encourage more complete participation? Are there any policy or legal challenges to encouraging participation?

ANSWER 3:

The former astronauts are for the most part committed to continuing to support NASA's mission through any route possible, including participation in the LSAH. NASA believes that its legislative proposal to increase the scope of the testing and provide diagnosis and treatment will add value to the former crew member and will likely encourage greater participation.

QUESTION 4:

The number of commercial spaceflight companies continues to grow and it is possible that in the future there will be private astronauts who have never flown in space as government employees. Do current NASA human spaceflight policies allow for such individuals to participate in studies like the Lifetime Surveillance of Astronaut Health study?

ANSWER 4:

No. The current program is an occupational health monitoring model designed for current and former government employees.

QUESTION 5:

Is there an ethical obligation to provide for the monitoring, diagnosis, and treatment of retired astronaut spaceflight-related injury or disease? If so, does the government's obligation apply without qualification of service? For example, should it extend to payload specialists?

ANSWER 5:

The IOM has made the case that there is an ethical obligation to provide such services. However, the focus of NASA's legislative proposal is on gathering improved data. NASA's legislative proposal thus includes payload specialists.

QUESTION 5a:

Although NASA strives to make spaceflight as safe as possible, it is inherently dangerous. As a nation, we have concluded that the importance of space exploration justifies accepting some level of risk. There are current processes through the Department of Labor and the Department of Veterans Affairs to provide treatment

for federal employees and service members who require treatment for conditions related to their service. How are these processes insufficient?

ANSWER 5a:

The Department of Labor (DOL) has a well-designed process to support civilian employees for injuries or death due to their occupation. The Department of Veterans Affairs (VA) has benefits programs to compensate and provide healthcare to former servicemembers and their survivors for disability or death related to their active service. NASA's legislative proposal is different in kind from the above. NASA seeks the authority to provide comprehensive care – medical monitoring, testing, diagnosis and treatment - for former crew members. One of the most critical elements of this plan is that if NASA can provide this ongoing medical care for former astronauts, participation in LSAH will increase and, with more extensive data, NASA will better be able to better understand the effects of spaceflight, with the aim of improving safety for future space travel.

QUESTION 6:

The National Academies of Sciences has recommended that NASA take a page from military retirement policy and assume responsibility for the lifelong healthcare of former astronauts. Do you agree or disagree? How should this responsibility affect existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits)?

ANSWER 6:

The National Academies of Science has made the case that there is an ethical obligation to provide such services. The focus of NASA's legislative proposal, however, is the scientific imperative of gathering as much data as possible to understand the health effects of spaceflight.

There would be no effect on existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits).

QUESTION 7:

Is there a clear, bright line that cleanly distinguishes between medical procedures providing monitoring, diagnosis, or treatment? Which of these are covered under NASA's existing research authority and which are not? Do you have specific examples? If NASA occupational health monitoring discovers a health problem during a routine monitoring visit, does NASA have the authority to begin treatment immediately?

ANSWER 7:

No, there isn't a clear, bright line that cleanly distinguishes between medical procedures providing monitoring, diagnosis, or treatment.

Monitoring can be considered the adoption, provision, and management of medical screening tests for an individual astronaut to provide evidence for conditions suspected to be associated with the astronaut occupation. It provides for early detection of a disease before any symptoms exist.

Medical diagnosis is based on information from sources such as findings from a physical examination, interview with the patient or family or both, medical history of the patient and family, and clinical findings as reported by laboratory tests and radiologic studies. It leads to the determination of the nature and/or cause of the symptoms.

Medical treatment is the professional management and care of a patient to combat a disease or disorder.

NASA has the authority to provide medical and dental care to and observation and study of crew members while on active duty with NASA. This care encompasses all aspects related to the mission, including certification and training, and all spaceflight mission phases. The LSAH provides an annual "Executive Physical" for management astronauts (who are still current employees but no longer flight-eligible) and retired astronauts who are no longer federal employees. This is limited in nature and does not provide the authority for diagnosis or ongoing medical treatment. NASA exercises its authority to conduct these occupational surveillance and research programs pursuant to the Space Act, 51 U.S.C. § 20113 *et seq*; 29 U.S.C. § 668; 5 U.S.C. § 7901.

An illustrative example might be:

A former astronaut participating in the LSAH program returns to the JSC Flight Medicine Clinic for his/her annual health status assessment, which includes a full body examination (monitoring). During the course of the examination, the NASA flight surgeon notes an irregular or suspicious mole. Under present authority, the NASA physician would then refer the former astronaut to his primary care physician or directly to a dermatologist for follow up. The dermatologist decides to remove the mole and sends the biopsied tissue for analysis (diagnosis). If the results are positive for a dangerous melanoma, an appropriate course of radiation and/or chemotherapy will be designed by an oncologist or cancer treatment center (treatment).

Apart from rendering first aid, NASA has no authority to immediately provide treatment for former astronauts.

QUESTION 8:

In your testimony, you said that NASA wants authority to provide management and retired astronauts with medical monitoring, diagnosis, and treatment for

psychological and medical conditions deemed by NASA to be associated with human spaceflight. This means that in practice, NASA will likely be defining in regulation what the standard of "associated with human spaceflight will be." In your opinion, what will this standard be? And what process will NASA take to define, and refine, what is and is not associated with human spaceflight? Will this standard be higher or lower than existing standards under FECA or at the VA?

ANSWER 8:

NASA is still developing the evidence base to understand whether medical conditions are associated with spaceflight. There are some medical conditions that we know are caused by spaceflight. However, for other conditions the causal relationship, if any, to spaceflight is still unknown.

NASA anticipates a process that incorporates review by appropriate internal and external nationally recognized subject matter experts.

The NASA process will be unique to the Agency and will inform its decision-making.

QUESTION 9:

The 2005 NASA Authorization Act instructed the Administrator to "develop a plan to better understand the longitudinal health effects of space flight on humans" considering "the need for the establishment of a lifetime health care program for NASA astronauts and their families or other methods to obtain needed health data from astronauts and retired astronauts." According to the Inspector General, NASA requested a feasibility study from the University of Nebraska Medical Center that estimated the cost of providing such care and identified three options using existing coverage platforms: (1) the existing Department of Defense program for military retirees and their dependents (Tricare), (2) private insurance, and (3) the Federal Employees Health Benefits Program. The cost of these options ranged from \$2.4M to \$6.5M per year for a population of 367 current and retired astronauts and their families. According to your testimony, NASA's current approach would be to only provide lifetime health care for NASA astronauts, *not their families*. Do you have an estimate for providing lifetime health care for NASA astronauts without their families? Do you have an estimate for simply providing treatment for conditions derived from spaceflight?

ANSWER 9:

No. NASA's legislative proposal addresses enhanced astronaut occupational health monitoring, with remediation of occupationally related disease. NASA does have an estimate for providing enhanced occupational health monitoring for former astronauts. NASA has estimated that the enhanced occupational model will cost the Agency an additional \$400,000 annually – bringing the total of the program to \$800,000. NASA does not anticipate needing additional appropriated funds for this purpose.

Sufficient evidence to provide reliable estimates for treatment has not yet been accumulated given both the relatively small population of astronauts and the duration of their occupation.

QUESTION 10:

In addition to orbital spaceflights, NASA may also send people on suborbital space flights. While technically, such persons would have endured space travel, they would not likely have been exposed to the same physiological effects of orbital space flight. If NASA is granted additional occupational health authority, should this be extended to persons who only experienced suborbital space flight? Does NASA plan to take on responsibility for the long-term health of astronauts (or scientists if they are not formally designated as astronauts) who have flown in suborbital space, or who have not flown in space at all?

ANSWER 10:

This legislative proposal is targeted at career NASA astronauts (and payload specialists) who have trained or flown in orbital spaceflights. Individuals participating in suborbital flights would not be eligible for participation in our astronaut health care effort.

QUESTION 11:

If NASA was granted additional authority to provide for diagnosis and treatment, will a retired astronaut be able to choose his or her own doctors? Or will they be mandated to use NASA medical doctors?

ANSWER 11:

NASA believes it is the best practice to work with the astronaut to determine where the best care for the specific illness would likely be found. The program is voluntary and former astronauts will always have the right to choose their own personal physician. NASA would request access to all the data regardless of the ultimate provider.

QUESTION 12:

Would NASA acceptance of the obligation to treat the long-term medical consequences of spaceflight affect the discussions that NASA has with its astronauts about risk, mitigation, and the willingness to accept risk? Would this long-term obligation for astronaut health care end up making NASA less risk tolerant? Or would the establishment of this long-term obligation make both NASA and its astronaut corps more willing to accept the health risks of human spaceflight?

ANSWER 12:

No. This will have no effect. NASA will continue to provide the evidence it has about the long-term health risks of spaceflight to the astronaut regardless of authorization.

No, it would not make NASA less risk tolerant, only more informed.

The risks of spaceflight to the astronaut will be greater as NASA moves on to deep space exploration and planetary excursion missions. NASA will work as diligently as it does now to identify and mitigate the hazards to the crew members. Certainly, a robust Astronaut Occupational Health Program, providing both monitoring and treatment, is instrumental to understanding the risks and mitigating any potential adverse health outcomes.

QUESTION 13:

Is NASA the only organization with sufficient expertise in space-related illnesses to adequately address astronaut health issues? If so, how does NASA plan to address ongoing treatment of chronic medical conditions, up to and including full-time convalescent or end-of-life care?

ANSWER 13:

NASA is the only U.S. agency that sends humans to space, and has the largest collection of spaceflight exposure data, aggregation of aerospace clinical expertise, and maintenance of the permanent healthcare records of astronauts during their careers. NASA does continue to collaborate with other Government Agencies and Military Branches to share knowledge when other occupations' risks lend themselves to understanding spaceflight illness and treatment best practices.

NASA's aerospace medical expertise is most knowledgeable for recognizing unique signs and symptoms of injuries or illnesses associated with being an astronaut. The specific clinical capabilities that the Agency has to treat spaceflight related disease is however limited. Instead, like NASA routinely does when addressing the healthcare needs of the active astronaut population, the Flight Medicine Clinic relies on other world class medical capabilities/facilities to administer specialized treatment and care.

QUESTION 14:

If NASA received additional authority to provide for treatment and diagnosis of former astronauts, how will the cost of these long-term health care services be budgeted? Will they be included into human space exploration lifecycle cost estimates for new systems, programs, or missions?

ANSWER 14:

The enhanced occupational health monitoring would be funded under existing appropriations through Human Space Flight Operations as requested in the FY 2017 President's Budget Request. NASA does not expect that treatment of serious health conditions will be included in the human space exploration lifecycle cost estimates for new systems, programs, or missions. For serious occupational injury or illness claims, NASA anticipates using funds already appropriated for these purposes.

QUESTION 15:

Retired civilian NASA astronauts, as former federal employees, are currently able to claim workers' compensation under the Federal Employees' Compensation Act (FECA). Receiving awards under FECA requires a determination that the injury or illness claimed was associated with federal work. Given that some health effects of spaceflight, such as cancer from radiation, do not appear until years after spaceflight has ended, do astronauts have difficulty proving cause under FECA?

ANSWER 15:

Nothing in this proposal precludes a civilian astronaut from filing a FECA claim. While the DOL's Office of Workers' Compensation Programs (OWCP) routinely handles claims involving latent occupational injuries, it is recognized that astronauts do experience unique exposures as a result of their time in space and the development and maintenance of medical and scientific expertise in understanding the links between that exposure and future illnesses will assist astronauts in supporting their claims for benefits under FECA, as well as OWCP in adjudicating those claims. If the proposed legislation becomes law, both NASA and OWCP agree they would have to coordinate in the implementation of this program, as well as engage in continuous coordination once the program has been established.

QUESTION 16:

There are only a few hundred retired astronauts. This is a very small population from which to derive statistically relevant evidence that spaceflight activities are associated with certain medical conditions. What is the standard for a determination of a FECA claim and how do the challenges of establishing a relationship between certain health issues and spaceflight impact FECA claim determinations?

ANSWER 16:

Nothing in this proposal precludes a civilian astronaut from filing a FECA claim. While the DOL's Office of Workers' Compensation Programs (OWCP) routinely handles claims involving latent occupational injuries, it is recognized that astronauts do experience unique exposures as a result of their time in space and the development and maintenance of medical and scientific expertise in understanding the links between that exposure and future illnesses will assist astronauts in supporting their claims for benefits under FECA, as well as OWCP in adjudicating those claims. If the proposed legislation becomes law, both NASA and OWCP agree they would have to coordinate in the implementation of this program, as well as

engage in continuous coordination once the program has been established.

QUESTION 17:

If the Department of Labor relies on NASA for subject matter expertise to determine if spaceflight contributed, precipitated, accelerated, or aggravated a health problem purportedly connected to an occupational hazard, why is it necessary to give NASA new authority? Doesn't NASA already play a significant role in the existing process?

ANSWER 17:

Nothing in this proposal precludes a civilian astronaut from filing a FECA claim. While the DOL's Office of Workers' Compensation Programs (OWCP) routinely handles claims involving latent occupational injuries, it is recognized that astronauts do experience unique exposures as a result of their time in space and the development and maintenance of medical and scientific expertise in understanding the links between that exposure and future illnesses will assist astronauts in supporting their claims for benefits under FECA, as well as OWCP in adjudicating those claims. If the proposed legislation becomes law, both NASA and OWCP agree they would have to coordinate in the implementation of this program, as well as engage in continuous coordination once the program has been established.

QUESTION 18:

If the Department of Labor relies on NASA for subject matter expertise to determine if spaceflight contributed, precipitated, accelerated, or aggravated a health problem purportedly connected to an occupational hazard, is there any recourse for claims where NASA doctors have not established, with medical certainty, that spaceflight contributes to, aggravates, accelerates, or precipitates a particular health problem? Vision problems associated with human spaceflight weren't clearly identified until about five years ago. Would astronauts filing claims related to space-related vision problems have had any recourse prior to the formal 2011 identification of a link between spaceflight and vision problems?

ANSWER 18:

Nothing in this proposal precludes a civilian astronaut from filing a FECA claim. While the DOL's Office of Workers' Compensation Programs (OWCP) routinely handles claims involving latent occupational injuries, it is recognized that astronauts do experience unique exposures as a result of their time in space and the development and maintenance of medical and scientific expertise in understanding the links between that exposure and future illnesses will assist astronauts in supporting their claims for benefits under FECA, as well as OWCP in adjudicating those claims. If the proposed legislation becomes law, both NASA and OWCP agree they would have to coordinate in the implementation of this program, as well as engage in continuous coordination once the program has been established.

QUESTION 19:

If NASA was granted authority to monitor, diagnosis, and treat retired astronauts for psychological and medical conditions *deemed by the NASA Administrator associated* with human space flight, how, if at all, would this determination impact a FECA claim?

ANSWER 19:

This will have no impact on FECA claims. Nothing in this proposal precludes a civilian astronaut from filing a FECA claim. While the DOL's Office of Workers' Compensation Programs (OWCP) routinely handles claims involving latent occupational injuries, it is recognized that astronauts do experience unique exposures as a result of their time in space and the development and maintenance of medical and scientific expertise in understanding the links between that exposure and future illnesses will assist astronauts in supporting their claims for benefits under FECA, as well as OWCP in adjudicating those claims. If the proposed legislation becomes law, both NASA and OWCP agree they would have to coordinate in the implementation of this program, as well as engage in continuous coordination once the program has been established.

QUESTION 20:

How many astronauts have filed FECA claims? How many of those claims have been adjudicated in favor of the astronauts? What was the nature of the injuries? Please explain NASA's role in the FECA process for those astronauts? What issues were identified that necessitated new authorities?

ANSWER 20:

As our response will become public record, we are providing you the most information we can without violating the privacy rights of those who filed claims.

There are 12 claims total. Some were for survivor benefits, the rest were for traumatic injury. None of the claims are for occupational disease. All claims were accepted. Some were provided survivor benefits, the rest were provided medical benefits only.

According to our records, of the 12 cases, for two astronauts the initial insult or exposure was traced to their active status but it wasn't until they transitioned to management astronaut that an official claim was filed. The remaining 10 claims were filed during active status or directly related to an occupational fatality. Of the traumatic injury claims, most were musculoskeletal injuries and one was hearing loss. No claims were filed by a former astronaut after they retired from NASA.

Astronauts who are injured in the performance of duty who suffer either traumatic injuries or develop an occupational disease may file a claim with the Federal Employees' Compensation Act, which is administered by the Department of Labor. Survivors may file claims on behalf of deceased astronauts. NASA currently assists astronauts with those claims. NASA has not been authorized to use appropriated funds to provide on-going medical care for retired astronauts that may be result of

exposure to space. Without this authority, NASA is unable to provide preventive health monitoring that should be accomplished for retired astronauts following their space flight exposures or to appropriately remedy such conditions.

In the absence of an accepted covered injury, the FECA does not provide for medical monitoring and testing of the type needed here.

Pursuant to 29 U.S.C. § 668, it is the responsibility of each agency to establish an occupational and safety program and provide a safe environment for its employees. NASA's authority to provide occupational safety and health programs is limited to current federal employees. See 5 U.S.C. § 8901.

<https://www.opm.gov/policy-data-oversight/worklife/health-wellness/#url=healthservices> Executive Order 12196 "Occupational Safety and Health Programs for Federal Employees."

QUESTION 21:

Civilian federal employees, including civilian astronauts, may be eligible for treatment and/or compensation under the Federal Employee Compensation Act (FECA) if they (or their survivors) can demonstrate an employment-related illness, injury, or death. To what extent could FECA, or modifications to FECA, meet the lifetime needs of astronauts for diagnosis and treatment of service-related health conditions?

ANSWER 21:

NASA does not believe that amending FECA is the best way for NASA to accomplish the important goal of studying the effects of occupational exposures in space, conducting monitoring of our astronaut population, getting data from health care providers, and providing comprehensive health care to current and former astronauts. NASA's proposal is different in kind from what FECA provides. NASA will continue to work with DOL on areas that are unique to astronaut spaceflight-related claims.

QUESTION 21a:

If Congress chose to take this approach, what changes to FECA would you recommend, to accommodate the unique circumstances of astronauts and the unique occupational exposures they receive in space?

ANSWER 21a:

NASA will continue to work with DOL on areas that are unique to astronaut spaceflight-related claims.

QUESTION 21b:

If Congress made changes to FECA in order to meet the occupational healthcare needs of civilian astronauts, what issues would remain for astronauts who are military service members?

ANSWER 21b:

As discussed above, NASA's proposal is different in kind.

QUESTION 22:

In some cases, it may be difficult or impossible to determine whether a particular health condition results from occupational exposure during spaceflight, or whether that exposure was just one of multiple risk factors.

- a. Since the Department of Labor was unable to send any of its 17,000 employees today, can you explain how the Department of Labor determines whether a particular condition qualifies under FECA? if occupational exposure increases the risk of that condition arising, but the condition can also arise without occupational exposure, how does the FECA treat that condition?

ANSWER 22a:

The DOL's OWCP would be best at addressing its internal procedures and policies for determination.

QUESTION 22b:

What assistance does NASA currently provide to the Department of Labor in making FECA eligibility determinations? What additional assistance could NASA provide? What additional assistance would the Department of Labor find useful? What barriers are there to providing additional assistance?

ANSWER 22b:

NASA has a claims worker at the Johnson Space Center to assist astronauts with the FECA claims filing process. While the decision to file and the burden of proof are solely the responsibility of the claimant, an agency such as NASA bears a responsibility to assist in filing of a claim and with the development of the evidence. This program (as other occupational monitoring programs have in the past) may well assist DOL in making its determinations.

QUESTION 22c:

To what extent could further research on astronaut health help to determine whether a particular condition was caused by occupational exposure in space?

ANSWER 22c:

The help cannot be overstated. As the Agency's challenges change to exploration class missions, the deep space and extra-planetary hazards are even less well understood than missions in Low-Earth Orbit. Coupled with the very small number of astronauts available to study, every bit of evidence becomes crucial.

QUESTION 23:

The medical conditions associated with spaceflight are not completely understood and are still the subject of significant debate. What type of aerospace medical expertise exists in the private sector to address these unique problems? Do any doctors in the private sector have experience treating such conditions or is NASA the only organization with the capability to treat them?

ANSWER 23:

NASA best understands the untoward exposures of spaceflight and has the only space medicine-specific expertise in the nation. NASA engages expertise across the private sector and other Government entities when seeking out how to better understand or treat medical conditions. Neurosurgeons, ophthalmologists, hyperbaric medicine specialists, cardiovascular specialists, bone specialists, emergency medicine experts, oncologists, immunologists, physiologists, behavioral specialists are just a few of the many consultants NASA aeromedical experts routinely seek out and collaborate with.

QUESTION 24:

Studies have shown that microgravity has a negative impact on bone density and health. In a microgravity environment do astronauts start losing bone mass immediately? Does this loss in bone density contribute to other health issues, such as an increased likelihood of fractures? Will an astronaut's bones return to "normal" – indistinguishable from the bones of a person who has never been exposed to microgravity — once they have returned to Earth? Is there any duration of *orbital* spaceflight short enough that we can safely assume doesn't pose any health risks?

ANSWER 24:

The loss of bone has been well documented and is measurable even during the relatively short flights the Shuttle underwent.

The demineralization of the bone does contribute to other health issues. For example, the formation of kidney stones is an outcome which can severely impact a crew member's ability to complete his or her mission. Ultimately, we are very concerned that the loss of bone and the subsequent restructuring of the bone architecture itself will lead to a higher risk of fractures in the astronauts.

Over time, the astronaut's bone density does return to normal or near normal values. However, there is evidence that the microarchitecture of the new bone is different from the Earth bound population. Some studies modeling this new bone predict that bone strength will be diminished.

It is currently unknown whether there is any duration of orbital spaceflight short enough that we can safely assume that there are no health risks. The bone loss risk is dose dependent.

QUESTION 25:

Some occupational health issues only come to light after epidemiologists have had years of data from thousands of affected workers to tease out subtle health effects. Given the size of the astronaut corps, do you think it will be practical to wait for rigorous studies needed to demonstrate links between time spent in space and various medical concerns that may arise from that time in space?

ANSWER 25:

This is the dilemma for NASA. For some adverse health outcomes it will be many decades, if ever, that statistical significance will clearly establish the causal link between an astronaut's occupational exposure and an adverse health outcome. Unlike occupations with thousands of workers to evaluate, the present system can fail those few we know are being routinely subjected to career hazards and risks unlike any other on Earth. It is for this very reason that NASA is asking to expand its occupational health authority.

QUESTION 26:

NASA has been sending astronauts into space for more than 55 years. During that time, it has developed considerable expertise about the potential health consequences of the space environment, how to prevent adverse consequences, and how to diagnose and treat them if they occur. Which are the most common—or the most concerning—health conditions that can arise in astronauts as a result of their service in space?

ANSWER 26:

There are volumes of scientific literature written on just this subject and virtually every human system is affected in one or more ways. Many health conditions become pronounced while the astronaut is still on the mission or very shortly after returning to Earth. As astronauts transition from the 1G environment of Earth to the microgravity environment of space, physiologic changes occur immediately. The neuro-vestibular system is challenged and can result in space motion sickness, the immune system becomes dys-regulated, the axial skeleton when unloaded begins to demineralize reducing bone strength, muscles unused in the microgravity environment atrophy, cognitive thinking becomes challenged, and fluid shifting from the lower extremities to the head and shoulders is believed to contribute to the recently described Visual Impairment Intracranial Pressure Syndrome (VIIP). Astronauts are of course subjected to increased levels of ionizing radiation increasing the risk of cancer. All health issues are concerning as they not only effect the astronaut's well-being but also potentially place the mission at risk. For missions in low Earth orbit, NASA has collected significant data and developed mitigation plans

to manage the conditions to promote mission success. Upon return to Earth, the astronauts take part in a well-planned physical and behavioral reconditioning and health monitoring plan. While hardly routine, NASA has developed considerable experience dealing with the more acute health risks associated with low-Earth orbit operations. New discoveries of previously unrecognized conditions are concerning, such as ‘white matter hyper-intensities’ in the brain. This condition, like VIIP, may have long-term health consequences that are completely outside of our experience base. Refer to NASA’s Human Research Program (HRP) research roadmap website (link: <https://humanresearchroadmap.nasa.gov/Risks/>).

QUESTION 27:

With current technology and scientific understanding, is human spaceflight intrinsically unsafe? Based on technological advancements and improved scientific understanding, can human spaceflight ever be made “safe”?

ANSWER 27:

It is intrinsically risky. However, astronauts are informed of those risks.

NASA will always strive to better understand and mitigate the hazards associated with spaceflight. Even if spaceflight became as commonplace as a daily commute to work, like with the automobile, we can only hope to continue to make it safer.

QUESTION 28:

Could NASA benefit from increased understanding regarding the correlation of health risk with low doses of radiation?

ANSWER 28:

Yes. Dose rate effects are our second largest uncertainty in understanding health risks from space radiation. (Quality effects are our largest uncertainty, i.e. the relative biological effectiveness of space radiation compared with terrestrial gamma radiation effects.)

QUESTION 29:

Has NASA used any of the research from the DOE’s low dose radiation research (LDRR) program, which the DOE has recently proposed to terminate. If DOE does not continue this research, has NASA considered how it will inform its risk assessment approach to astronauts’ health for long-term missions in space? Has NASA considered funding its own LDRR program and what would that cost?

ANSWER 29:

Yes, NASA and the U.S. Department of Energy's (DOE) Low Dose Radiation Research (LDRR) Program have collaborated on studies of mutual interest to extend our knowledge of the mechanisms of radiation-induced malignant transformation and correlation of risk based on epidemiological studies following low dose rate exposures. NASA is most reliant on the completion of the Million Person Study led by the National Council on Radiation Protection to more accurately inform astronaut health risks. This DOE-sanctioned study is an inter-agency mortality study of the early U.S. workers of the nuclear age. The DOE Low Dose Program, as well as NASA, the National Cancer Institute, U.S. Nuclear Regulatory Commission (NRC), Army, Air Force, Navy, Centers for Disease Control and Prevention, and US Environmental Protection Agency (EPA), are funding contributors. DOE facilitated an initial funding mechanism through the Low Dose Program for interagency contributions with the NRC, EPA, and NASA.

NASA is not considering its own LDRR Program, but includes low dose research within its current program plan. The NASA Human Research Program funds space radiation grants utilizing the NASA Space Radiation Lab located at the DOE Brookhaven National Laboratory in Upton, New York. Low dose research (<1 Gy) is performed by the Human Research Program for the NASA-unique requirements of single and mixed field proton, alpha, and heavy-ion research. The continued funding of the DOE LDRR program will support NASA to achieve its goal with increased certainty.

QUESTION 30:

Under the Health Insurance Portability and Accountability Act of 1996 (HIPAA), studies intended only for internal use—such as those used by an organization to develop its own treatment guidelines—are not required to meet the same privacy and patient authorization requirements as research studies intended for external use. Please describe any NASA studies that relate to astronaut health that are intended for internal NASA use only. If there are any such studies, how does NASA ensure appropriate protection of patient privacy in the absence of HIPAA protections?

ANSWER 30:

NASA is compliant with the Privacy Act of 1974 as amended and has policies and processes in place to protect medically sensitive information. NASA does not have any research studies that are intended for internal use only.

QUESTION 30a:

In its studies related to astronaut health, to what extent does NASA make its data and findings available to outside researchers, foreign space agencies, commercial spaceflight providers, or other non-NASA organizations? How does NASA ensure that these outside groups appropriately protect patient privacy?

ANSWER 30a:

NASA does make its data available. NASA's databases are query-able through an established data request process.

NASA has an extensive human research program and a robust privacy policy in place. NASA provides biomedical data to researchers and follows the NASA privacy procedural requirements in NPR 1382.1a and NPD 7100.8e.

QUESTION 30b:

Does NASA require reciprocal access to foreign space agency information?

ANSWER 30b:

For research studies, the individual crew member (NASA or other foreign space agency) makes the decision to release his or her data. For medical issues of common interests across international space flight partners, agreements are developed on what data will be shared and how each partner plans to safeguard the data. Reciprocity is often a key component of those agreements.

QUESTION 31:

In the 2004 National Academies Report, *Review of NASA's Longitudinal Study of Astronaut Health*, the Committee recommended that "NASA should recognize that the Longitudinal Study of Astronaut Health (LSAH) can and should serve the two separate and potentially conflicting goals of occupational surveillance of the health of current and former astronauts and research into the long-term health risks associated with manned space flight." Can you speak to the potential conflicting goals of the LSAH as it currently exists? And how, if at all, additional conflicting goals may arise if NASA was given additional authority to monitor, diagnosis, and treat retired astronauts?

ANSWER 31:

There will be no conflict. Both the research community and NASA's LSAH will benefit from improved data acquisition.

QUESTION 32:

If NASA was authorized to provide expanded medical monitoring, diagnosis, and treatment of retired astronauts, would this supplement or replace existing healthcare provided by other government programs? For example, many NASA astronauts are eligible for medical benefits under other programs such as the Veterans Administration, Medicare, Medicaid and Tricare. What would happen if different health care providers did not agree over who was responsible for paying, a likely outcome given how little we know about medical conditions associated with human spaceflight?

ANSWER 32:

This expanded authority will have no such impact on any of these programs.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

*Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing,
and Treating Former Astronauts*

Dr. Richard Williams, Chief Health and Medical Officer, NASA

Questions submitted by Rep. Donna F. Edwards, Ranking Member,
Subcommittee on Space

QUESTION 1:

How will NASA develop the body of evidence on the causality between space flight exposures and the development of diseases or other medical conditions, something that has eluded us to date? What is the basis of NASA's projection that participation in the Lifetime Surveillance of Astronaut Health program will increase from about 60 percent to 80 percent?

ANSWER 1:

As proposed, NASA will continue to expand its occupational monitoring program, increasing the highest level of evidence data available to establish the association between spaceflight exposures and adverse health outcomes. In addition, the analyses include other biomedical evidence from controlled spaceflight studies and draw upon related evidence from analogous ground based health data.

Presently, the percent participation varies year to year from about 60-70 percent of eligible former astronauts. Former crews have indicated that some colleagues do not presently participate due to a lack of perceived value. Although 100 percent participation is our goal, it was estimated that 4 out of 5 former crewmembers would agree to participate with expanded monitoring to include high value tests to them, such as mammography and behavioral health assessments.

QUESTION 2:

How would NASA's legislative proposal impact a former astronaut's continued use of his/her private medical insurance?

ANSWER 2:

There is no impact.

QUESTION 3:

With 60 percent of retired astronauts currently actively participating in the voluntary Lifetime Surveillance Astronaut Health program, NASA estimates current costs are about \$400,000 per year. NASA has told Committee staff that the conservative estimated annual costs to implement the expanded monitoring, surveillance, and

treatment program is \$800,000. What is the basis for this estimate? Does this include treatment of catastrophic conditions? If not, what is NASA's estimate of annual costs if catastrophic conditions are taken into account?

ANSWER 3:

The estimates include an evaluation of the composition of the astronaut cohort eligible to participate in expanded monitoring (present age, sex), leveraging historical astronaut data for retirement age data and age at death. The estimates further made allowances for future astronauts hired based on planning from the Astronaut Office. The proposed schedules for the additional monitoring tests were based on modifications to commonly recommended testing schedules (e.g., U.S. Preventive Services Task Force). The budget estimates were then based on cost actuals for testing from the Johnson Space Center Flight Medicine Clinic.

It is critical to distinguish that this budget analysis only considered increases due to expanding the NASA Lifetime Surveillance Astronaut Health (LSAH) health monitoring test battery. It does not include costs of future treatments. Sufficient evidence to provide reliable estimates for treatment has not yet been accumulated given the relatively short history with the astronaut occupation and very small population of space explorers. This proposal will have no effect on the current statutory processes in which current and former federal employees may file claims for compensation with the Department of Labor (DOL) or with the Department of Veterans Affairs (VA) for injuries or death sustained in the performance of their duties.

QUESTION 4:

With regard to the proposed enhanced medical monitoring that participating astronauts will undergo:

- a. How often will astronauts be examined?

ANSWER 4a:

Annual examinations will be requested but not all tests will be performed at each visit.

QUESTION 4b:

What are some of the tests they can expect to undergo?

ANSWER 4b:

Specific test protocols must all be evaluated and approved through NASA review processes. Likely candidates for immediate adoption include cancer screening tests, such as mammography; behavioral assessments, such as cognitive testing; and specific testing for ophthalmologic follow up.

QUESTION 4c:

Will astronauts have an opportunity to decline a subset of these tests at their discretion?

ANSWER 4c:

Yes, that is their right.

QUESTION 4d:

How would NASA ensure that the monitoring and use of data are voluntary?

ANSWER 4d:

Participation presently is voluntary. NASA does not propose any compulsory measures with this authorization. The basic tenet for proposing the legislation has always been two-fold. One, it is in the Agency's interest to collect as much long-term health data as possible to safely advance our future missions. Two, the Agency wants to monitor and detect as early as possible any adverse health outcomes associated with the hazards of the astronaut occupation. NASA has policies and processes in place to safeguard the use of these data.

QUESTION 5:

NASA believes there is a strong relationship between expanding health surveillance of active and retired astronauts and the safe pursuit of NASA's human exploration program. What are some specific examples of how data acquired through expanded health screening would help mitigate future safety risks?

ANSWER 5:

Understanding the untoward health effects of spaceflight exposures, such as cancers, cataracts, visual changes, reduced bone strength and fracture, and injuries resulting from operations, is imperative to the design and implementation of effective countermeasures. These conditions, and other conditions as yet undiscovered, provide specific examples of how data acquired through expanded health screening would help mitigate future safety risks.

QUESTION 6:

Due to the small size of the astronaut corps, is it difficult to ensure that the identity of individual astronauts is protected when making their data available to researchers? What steps has NASA taken to protect the privacy of their astronauts, and what, if any, additional steps would NASA take to protect privacy under the legislative proposal?

ANSWER 6:

NASA has an extensive human research program in place and ensures that it complies with the Privacy Act of 1974, as amended, as well as our robust privacy data protection policies. Specifically, NASA follows the privacy procedural requirements in NPR 1382.1a and NPD 7100.8e. No changes to these policies are envisioned.

Responses by Captain Chris Cassidy

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

*Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing,
and Treating Former Astronauts*

Captain Chris Cassidy, United States Navy (USN); Chief, Astronaut Office, NASA

Questions submitted by Rep. Brian Babin, Chairman, Subcommittee on Space

QUESTION 1:

What challenges do retired astronauts face in the monitoring, diagnosis, and treatment of spaceflight-related injury or disease? And what, if anything, should be done by NASA to better address such challenges?

ANSWER 1:

Many retired astronauts do not participate in the Lifetime Surveillance of Astronaut Health (LSAH) study and thus are neither afforded a comprehensive picture of 1) what known risks remain after a spaceflight career (radiation induced cancer, cardiovascular disease (CVD), central nervous system (CNS) effects, Visual Impairment and Intracranial Pressure (VIIP) long-term effects, vulnerability to shoulder injuries, etc.), nor 2) what organs and systems are affected by spaceflight and are not known to be, but may be, at risk of disease (bone, muscle, broad CNS effects, etc.). NASA has proposed to the Congress a more comprehensive program of monitoring, diagnosis, and treatment of retired astronauts.

QUESTION 2:

What is your personal perspective on the treatment you have received from NASA? What changes would you personally most like to see in how astronauts are treated?

ANSWER 2:

In almost all cases, the personal relationships between astronauts and NASA flight surgeons/ space medicine specialists is outstanding – the office of the flight surgeons is generally viewed as very supportive of the flight career. This may be distinguished from, and be even better than, the military equivalent. What is needed is a framework that allows that support to continue post-career and be shifted from the mission support paradigm toward long-term comprehensive surveillance and treatment.

QUESTION 3:

Testimony indicated that management astronauts are not provided the same comprehensive monitoring, diagnosis, and treatment that active astronauts are provided. What prevents NASA from treating management astronauts if they deem it necessary?

ANSWER 3:

Management astronauts do not continue to participate in spaceflight, and so are currently treated the same as post-flight career astronauts. This is a result of the current program paradigm that focuses primarily on mission support. NASA believes they need the same comprehensive surveillance and treatment program.

QUESTION 4:

The retired astronaut corps is made up of men and women, of all ages, living across the United States, and indeed the world. Right now, if retired astronauts want to avail themselves of NASA's medical monitoring program, they must fly to Johnson Space Center and agree to have their medical data made available for scientific purposes. If NASA was authorized to provide for more comprehensive monitoring, diagnosis, and treatment of retired astronauts, what would the retired astronaut community recommend NASA do practically to better meet their medical needs? For example, should NASA find a way to work with local practitioners, and not mandate astronauts fly to Johnson Space Center?

ANSWER 4:

NASA recommends the core of the surveillance program be located at the Johnson Space Center (JSC). It gives a better chance at standardizing information collection and recording, and would also be conducted directly by those knowledgeable of and responsible for space medicine practices. The chances of finding career related issues should be highest at JSC. Reality dictates some retired astronauts will be unable to travel for each encounter due to busy lives or advanced years, so a combination approach that also involves standardized methods seems prudent. This approach would also allow for the use of the optimum diagnostic methods and treatment for certain space related disorders, which may not be in the JSC proximity.

QUESTION 5:

NASA has told the committee that 61 percent of retired astronauts participate in the Lifetime Surveillance of Astronaut Health (LSAH) study. What can be done to encourage more complete participation? Are there any policy or legal challenges to encouraging participation?

ANSWER 5:

Certainly the promise of lifetime surveillance and healthcare will be a huge incentive, instead of the piecemeal examinations currently available, and the knowledge that if something is found the retired astronaut must acquire further treatment on their own. In addition, I believe the character of astronauts will drive them to participate knowing that, aside from personal health, their participation will contribute to a more complete understanding of the response to human spaceflight. The primary legal challenge is in attaining the authorization to form and implement such a program. The primary policy challenge is ensuring that data collection will be standardized and results used in a non-attributable fashion.

QUESTION 5a:

As an astronaut, can you give us a sense why some of your retired colleagues choose not to participate in the study?

ANSWER 5a:

There are many factors, including most notably the time to travel to JSC, an unclear sense of purpose for the examinations, and the blurred lines between NASA and private insurance provisions.

QUESTION 6:

Is there an ethical obligation to provide for the monitoring, diagnosis, and treatment of retired astronaut spaceflight-related injury or disease? If so, does the government's obligation apply without qualification of service? For example, should it extend to payload specialists?

ANSWER 6:

The Institute of Medicine (IOM) report makes a case that there is an ethical obligation. I personally agree with the IOM that there is an ethical obligation to take care of our astronauts that we put in harm's way. However, NASA's primary reason for requesting the more comprehensive program of monitoring, diagnosis, and treatment of retired astronauts, is the important data that can be gained from such a program.

QUESTION 6a:

Although NASA strives to make spaceflight as safe as possible, it is inherently dangerous. As a nation, we have concluded that the importance of space exploration justifies accepting some level of risk. There are current processes through the Department of Labor (DOL) and the Department of Veterans Affairs (VA). VA to provide treatment for federal employees and service members who require treatment for conditions related to their service. How are these processes insufficient?

ANSWER 6a:

The Department of Labor (DOL) has a well-designed process to support civilian employees and their families in the event of an occupational injury or death. The Department of Veterans Affairs (VA) has benefit programs to compensate and provide healthcare to former service members and their survivors for disability or death related to their active service. NASA's legislative proposal is different in kind from the above. NASA seeks the authority to provide comprehensive care – medical monitoring testing, diagnosis and treatment - for former crew members. One of the most critical elements of this plan is that if NASA can provide this ongoing medical care for former astronauts, participation in LSAH will increase and, with more extensive data, NASA will better be able to better understand the effects of spaceflight, with the aim of improving safety for future space travel.

QUESTION 7:

The National Academies of Sciences has recommended that NASA take a page from military retirement policy and assume responsibility for the lifelong healthcare of former astronauts. Do you agree or disagree? And why? How should this responsibility affect existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits)?

ANSWER 7:

Yes, I agree. I believe there is an obligation on the part of any employer to exercise due diligence to study all occupational hazards that its employees may encounter in the workplace, to understand the short- and long-term health effects of those dangers, and to provide care for former employees who suffer health issues as a result of their service, an idea addressed in the Institute of Medicine report. There would be no effect on existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits).

QUESTION 8:

Would NASA acceptance of the obligation to treat the long-term medical consequences of spaceflight affect the discussions that NASA has with its astronauts about risk, mitigation, and the willingness to accept risk? Would this long-term obligation for astronaut health care end up making NASA less risk tolerant? Or would the establishment of this long-term obligation make both NASA and its astronaut corps more willing to accept the health risks of human spaceflight?

ANSWER 8:

I expect that the surveillance and treatment of long-term medical consequences of spaceflight will certainly be part of the discussions that the Agency has with astronauts as well as the rising commercial spaceflight population. We are an evidence and information driven agency and having facts on the table is central to our operation. There may be some personal choices influenced by the comprehensive health care program, as well as what findings result from it over the

years, but this will likely have little influence on the risk tolerance of the astronaut corps or the Agency. I believe risk tolerance is a peripheral question; again, this is the right thing to do for the astronaut cadre as well as a public right to know.

QUESTION 9:

Retired civilian NASA astronauts, as former federal employees, are currently able to claim workers' compensation under the Federal Employees' Compensation Act (FECA). Receiving awards under FECA requires a determination that the injury or illness claimed was associated with federal work. Given that some health effects of spaceflight, such as cancer from radiation, do not appear until years after spaceflight has ended, do astronauts have difficulty proving cause under FECA? Are you more comfortable allowing the NASA Administrator discretion to determine whether a condition was caused by space flight, or an independent body as is currently structured under FECA for former federal employees?

ANSWER 9:

As explained more fully in Question 6a, the Department of Labor's process for federal employees addresses occupational injury (including disability and death due to that injury). NASA's legislative proposal is different in kind from the above. NASA seeks the authority to provide comprehensive care – medical monitoring testing, diagnosis and treatment - for former crew members. One of the most critical elements of this plan is that if NASA can provide this ongoing medical care for former astronauts, participation in LSAH will increase and, with more extensive data, NASA will better be able to better understand the effects of spaceflight, with the aim of improving safety for future space travel.

QUESTION 10:

Civilian federal employees, including civilian astronauts, may be eligible for treatment and/or compensation under the FECA if they (or their survivors) can demonstrate an employment-related illness, injury, or death. To what extent could FECA, or modifications to FECA, meet the lifetime needs of astronauts for diagnosis and treatment of service-related health conditions?

- a. If Congress chose to take this approach, what changes to FECA would you recommend, to accommodate the unique circumstances of astronauts and the unique occupational exposures they receive in space?
- b. If Congress made changes to FECA in order to meet the occupational healthcare needs of civilian astronauts, what issues would remain for astronauts who are military service members?

ANSWER 10a&b:

NASA does not believe that amending FECA is the best way for NASA to accomplish the important goal of studying the effects of occupational exposures in space, conducting monitoring of our astronaut population, getting data from health care providers, and providing comprehensive health care to current and former astronauts. NASA's proposal is different in kind from what FECA provides. NASA will continue to work with DOL on areas that are unique to astronaut spaceflight-related claims.

QUESTION 11:

Should the provision of monitoring, diagnosis, and treatment of retired or management astronaut spaceflight-related injury or disease be conditioned on participants agreeing to share their health data with NASA for scientific purposes? Or should NASA provide this services without condition, allowing the astronauts to decide whether or not, and in what capacity, their data is shared for scientific purposes?

ANSWER 11:

Collection of data and provision of health care for career related conditions and exposure are two vital but independent obligations of the federal government and human spaceflight program. The same is true in the Department of Defense where unknown issues arise periodically as a result of career exposures. All astronauts participate in human spaceflight with the notion of furthering knowledge, and, in general, participation in data sharing is very high. Along with the appropriate safeguards to de-attribute data, I expect the quantity and quality of such high value scientific data to drastically increase with the desired comprehensive surveillance and treatment program.

QUESTION 12:

A 2014 report by the National Academies brings up ethical issues associated with releasing sensitive health information. It is the right of an individual to maintain the privacy of his or her medical information. However, in the case of retired astronauts, that very information can be used to protect the health of future astronauts. As astronauts what are your feelings about this issue? What is the general sense in the astronaut community about this dilemma?

ANSWER 12:

The knowledge can be used in an attributable fashion in-house while still protecting the individual but immediately influencing health of successor crewmembers. Vision Impairment and Intracranial Pressure (VIIP) is a great example; with a few index cases, a universal monitoring program was quickly implemented well before the first paper was released with a de-attributed clinical data set. It is always the right of an individual to protect medical privacy, but that does not mean their information is not applied positively to the health outcomes of the greater astronaut

corps. However, with the correct infrastructure and controls in place, pooled data is available for wider analysis and release to the academic community.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

*Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing,
and Treating Former Astronauts*

Captain Chris Cassidy, United States Navy (USN); Chief, Astronaut Office, NASA

Questions submitted by Rep. Donna F. Edwards, Ranking Member,
Subcommittee on Space

QUESTION 1:

What factors do you believe might influence active and retired astronauts when deciding whether or not to participate in the lifetime regimen of clinical surveillance proposed by NASA?

ANSWER 1:

There are many factors, including most notably the time to travel to the Johnson Space Center, an unclear sense of purpose for the examinations, and the blurred lines between NASA and private insurance provisions.

QUESTION 2:

With regards to ensuring that the identity of individual astronauts is protected when making their health data available to researchers, are you satisfied with the steps NASA has taken to protect the privacy of their astronauts?

ANSWER 2:

Yes, I am satisfied with the steps NASA has taken to protect the privacy of their astronauts. The knowledge can be used in an attributable fashion in-house while still protecting the individual but immediately influencing health of successor crewmembers. Vision Impairment and Intracranial Pressure (VIIP) is a great example; with a few index cases, a universal monitoring program was quickly implemented well before the first paper was released with a de-attributed clinical data set. It is always the right of an individual to protect medical privacy, but that does not mean their information is not applied positively to the health outcomes of the greater astronaut corps. However, with the correct infrastructure and controls in place, pooled data is available for wider analysis and release to the academic community.

QUESTION 3:

In the summary of his prepared statement, Captain Lopez-Alegria says that “*there is a private right to understand the comprehensive effects of spaceflight on human health as the democratization of access to space becomes a reality with the successes of commercial human spaceflight.*”

- a. Do you agree with his view that expanded surveillance, diagnosis, and treatment better inform future private citizens seeking to go to space?

ANSWER 3a:

Yes, expanded surveillance, diagnosis, and treatment will better inform future private citizens seeking to go to space. We expect that the surveillance and treatment of long-term medical consequences of spaceflight will certainly be part of the discussions that the Agency has with astronauts as well as the rising commercial spaceflight population. We are an evidence and information driven agency and having facts on the table is central to our operation. There may be some personal choices influenced by the comprehensive health care program, as well as what findings result from it over the years, but this will likely have little influence on the risk tolerance of the astronaut corps or the Agency. We believe risk tolerance is a peripheral question; again, this is the right thing to do for the astronaut cadre as well as a public right to know.

QUESTION 3b:

Do you have any concerns associated with NASA being required to share astronaut health data with citizens, private sector companies, and regulators such as the FAA?

ANSWER 3b:

No, I am satisfied with the steps NASA has taken to protect the privacy of their astronauts.

Responses by Captain Scott Kelly

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SPACE**

*Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing, and
Treating Former Astronauts*

Captain Scott Kelly, United States Navy (USN); Former Astronaut, NASA

Questions submitted by Rep. Brian Babin, Chairman, Subcommittee on Space

Question 1:

What challenges do retired astronauts face in the monitoring, diagnosis, and treatment of spaceflight-related injury or disease? And what, if anything, should be done by NASA to better address such challenges?

Response 1:

I would like to see NASA focus on developing a program that both observes the status of its astronauts and is capable of treating them in case of illness. We need to focus on the outcomes that occur because of the unique environments in space that astronauts are exposed to. This includes radiation and carbon dioxide, and micro-gravity which results in a loss of bone and muscle, vision impairment and effects on our immune system.

Question 2:

What is your personal perspective on the treatment you have received from NASA? What changes would you personally most like to see in how astronauts are treated?

Response 2:

The treatment I have received from NASA has been great. Generally, there is a positive relationship between astronauts and the flight surgeons. What I would like to see is this relationship, rooted in comprehensive surveillance and treatment, continue beyond one's time in the astronaut corps.

Question 3:

The retired astronaut corps is made up of men and women, of all ages, living across the United States, and indeed the world. Right now, if retired astronauts want to avail themselves of NASA's medical monitoring program, they must fly to Johnson Space Center and agree to have their medical data made available for scientific purposes. If NASA was authorized to provide for more comprehensive monitoring, diagnosis, and

treatment of retired astronauts, what would the retired astronaut community recommend NASA do practically to better meet their medical needs? For example, should NASA find a way to work with local practitioners, and not mandate astronauts fly to Johnson Space Center?

Response 3:

There is a need for a centralized location to manage the activities around the surveillance program. It is logical that this be at JSC. The professionals at JSC are most familiar with the medical conditions that are unique to astronauts. However, I am aware of some astronauts that are not likely going to make it to Houston with regularity. Therefore, we need to make accommodations that enable them to be surveyed and allow them to participate in the program because this knowledge is so critical to the whole group.

Question 4:

NASA has told the committee that 61 percent of retired astronauts participate in the Lifetime Surveillance of Astronaut Health study. What can be done to encourage more complete participation? Are there any policy or legal challenges to encouraging participation?

Response 4:

I think this will be an easy sell to retired astronauts as long as the results are non-attributable to specific astronauts. Our commitment to furthering human spaceflight and exploration does not end when our time in space does. I believe retired astronauts will be enticed by a benefit of lifetime healthcare. We are in need of an authorization to form such a program that treats astronauts for the long-term.

Question 4a:

As an astronaut, can you give us a sense why some of your retired colleagues choose not to participate in the study?

Response 4a:

There are two major factors that drive negative participation. First, the travel required for astronauts to get to JSC. Second, the confusion that exists between NASA's coverage and that of military or private insurers.

Question 5:

Is there an ethical obligation to provide for the monitoring, diagnosis, and treatment of retired astronaut spaceflight-related injury or disease? If so, does the government's

obligation apply without qualification of service? For example, should it extend to payload specialists?

Response 5:

Yes, there is an ethical obligation to cover monitoring, diagnosis and treatment in addition to the implementation of a program to cover retired astronauts including payload specialists.

Question 5a:

Although NASA strives to make spaceflight as safe as possible, it is inherently dangerous. As a nation, we have concluded that the importance of space exploration justifies accepting some level of risk. There are current processes through the Department of Labor and the VA. A to provide treatment for federal employees and service members who require treatment for conditions related to their service. How are these processes insufficient?

Response 5a:

The current proposal is specific and tailor made to address the unique needs of NASA's astronauts.

Question 6:

The National Academies of Sciences has recommended that NASA take a page from military retirement policy and assume responsibility for the lifelong healthcare of former astronauts. Do you agree or disagree? And why? How should this responsibility affect existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits)?

Response 6:

I agree with this sentiment. Similar to the DoD's relationship with its employees, NASA has an obligation to its employees that are exposed to unique hazards while in space. This obligation spans beyond the time we are in space or working for NASA.

Question 7:

Would NASA acceptance of the obligation to treat the long-term medical consequences of spaceflight affect the discussions that NASA has with its astronauts about risk, mitigation, and the willingness to accept risk? Would this long-term obligation for astronaut health care end up making NASA less risk tolerant? Or would the establishment of this long-term obligation make both NASA and its astronaut corps more willing to accept the health risks of human spaceflight?

Response 7:

I believe that accepting the responsibility of providing long-term care could alter some of the conversations that NASA has with astronauts related to risk but ultimately it will not change the direction of the agency or impact the desired goals.

Question 8:

Retired civilian NASA astronauts, as former federal employees, are currently able to claim workers' compensation under the Federal Employees' Compensation Act (FECA). Receiving awards under FECA requires a determination that the injury or illness claimed was associated with federal work. Given that some health effects of spaceflight, such as cancer from radiation, do not appear until years after spaceflight has ended, do astronauts have difficulty proving cause under FECA? Are you more comfortable allowing the NASA Administrator discretion to determine whether a condition was caused space flight, or an independent body as is currently structured under FECA for former federal employees?

Response 8:

Due to lack of knowledge, I decline to comment on issues regarding FECA.

Question 9a&b:

Civilian federal employees, including civilian astronauts, may be eligible for treatment and/or compensation under the Federal Employee Compensation Act (FECA) if they (or their survivors) can demonstrate an employment-related illness, injury, or death. To what extent could FECA, or modifications to FECA, meet the lifetime needs of astronauts for diagnosis and treatment of service-related health conditions?

- a. If Congress chose to take this approach, what changes to FECA would you recommend, to accommodate the unique circumstances of astronauts and the unique occupational exposures they receive in space?
- b. If Congress made changes to FECA in order to meet the occupational healthcare needs of civilian astronauts, what issues would remain for astronauts who are military service members?

Response 9a&9b:

Due to lack of knowledge, I decline to comment on issues regarding FECA.

Question 10:

Should the provision of monitoring, diagnosis, and treatment of retired or management astronaut spaceflight-related injury or disease be conditioned on participants agreeing to share their health data with NASA for scientific purposes? Or should NASA provide this services without condition, allowing the astronauts to decide whether or not, and in what capacity, their data is shared for scientific purposes?

Response 10:

These items should remain separated. Although they are both critical government functions, they are not tethered as one. There is already a sense amongst the astronaut corps that data-sharing is a primary objective derived from their time in space, therefore, there is already a high rate of participation in health studies. There should be a strong focus on making sure that the data is non-attributable.

Question 11:

A 2014 report by the National Academies brings up ethical issues associated with releasing sensitive health information. It is the right of an individual to maintain the privacy of his or her medical information. However, in the case of retired astronauts, that very information can be used to protect the health of future astronauts. As astronauts what are your feelings about this issue? What is the general sense in the astronaut community about this dilemma?

Response 11:

I believe that a balance can be achieved that accomplishes the goal of improving astronaut health while protecting the personal information of the astronauts. The data received from flown astronauts is so valuable to future crews that not establishing a trusted system that jointly protects astronauts' health information and benefits future crews would be a missed opportunity.

Responses by Captain Michael Lopez-Alegria

House Committee on Science, Space and Technology
Subcommittee on Space

Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing and Treating Former Astronauts

Captain Michael Lopez-Alegria (USN, Ret.), President, Association of Space Explorers-
USA Former Astronaut, NASA

Responses to questions from Rep. Brian Babin,
Chairman

1. What challenges do retired astronauts face in the monitoring, diagnosis, and treatment of spaceflight-related injury or disease? And what, if anything, should be done by NASA to better address such challenges?

NASA's interpretation of the law is that they have no authority to provide monitoring, diagnosis or treatment of spaceflight-related injury or disease outside the auspices of the Lifetime Surveillance of Astronaut Health. As a result, any such monitoring, diagnosis or treatment for a retired astronaut is at personal expense. Worse, any data resulting from such medical attention is not, a priori, shared with NASA. It is clear that the situation must be changed to allow non-active astronauts to receive such medical attention, and that it be either performed, or at least organized, administered and paid for, by NASA. Whether that is within the purview of NASA's current authority is beyond my understanding, but it is clear that their current opinion is that it is not, and a legislative change would be required to implement such a change.

2. What is your personal perspective on the treatment you have received from NASA? What changes would you personally most like to see in how astronauts are treated?

At a minimum I am strongly in favor of the changes outlined in my response above. Further, since we can't presume to know all of the health effects of spaceflight, comprehensive medical care for retired astronauts (similar to that offered to active astronauts) would greatly increase our chances of detecting a previously unknown spaceflight-related condition (such as the Vision Impairment-Intracranial Pressure syndrome - VIIP, which emerged only in the last decade) to the benefit of our future human space exploration goals.

3. The retired astronaut corps is made up of men and women, of all ages, living across the United States, and indeed the world. Right now, if retired astronauts want to avail themselves of NASA's medical monitoring program, they must fly to Johnson Space Center and agree to have their medical data made available for scientific purposes. If NASA was authorized to provide for more comprehensive monitoring, diagnosis, and treatment of retired astronauts, what would the retired astronaut community recommend NASA do practically to better meet their medical needs? For example, should NASA find a way to work with local practitioners, and not mandate astronauts fly to Johnson Space Center?

I believe that a program to monitor, diagnose and treat spaceflight-related injury or disease should be centrally administered at the Johnson Space Center (JSC). The majority of the world's clinical and research medical experts either work in or around there, or have research that is managed there. The Flight Medicine Clinic at JSC has an

extensive network of knowledgeable health care providers that are familiar with the peculiarities of space medicine and are accustomed to sharing data. There are certainly some cases of retired astronauts whose physical condition makes it difficult to travel to Houston; in these circumstances local practitioners should absolutely be relied upon to provide the requisite care (and data sharing). But the main obstacle to having more retired astronauts go to JSC to participate in LSAH is that, with its current scope, it's simply not judged to be worth the considerable difficulty for some to make the trip. A more robust program that, at a minimum, included monitoring, diagnosis and treatment for known spaceflight-related conditions, and ideally encompassed comprehensive health care, would bring a vast majority of those currently not participating back to the program. The data gained from such a program would be a treasure trove for NASA researchers and clinicians alike.

4. NASA has told the committee that 61% of retired astronauts participate in the Lifetime Surveillance of Astronaut Health study. What can be done to encourage more complete participation? Are there any policy or legal challenges to encouraging participation?

See response #3 above.

- a. As an astronaut, can you give us a sense why some of your retired colleagues choose not to participate in the study?

Again, most who don't participate in the LSAH cite a cost-benefit analysis that simply does not tip the scale in favor of participation. Many retired astronauts have some medical conditions that require them to regularly see their own providers for check-ups, prescriptions, etc. They don't see the value in additionally traveling to Houston to see a NASA flight surgeon who isn't authorized to perform these simple medical services.

5. Is there an ethical obligation to provide for the monitoring, diagnosis, and treatment of retired astronaut spaceflight-related injury or disease? If so, does the government's obligation apply without qualification of service? For example, should it extend to payload specialists?

There is a moral and ethical obligation on the part of any employer to exercise due diligence to study all occupational hazards that its employees may encounter in the workplace, to understand the short- and long-term health effects of those dangers, to use all reasonable methods to prevent these risks from negatively impacting the wellbeing of its current and future workers, and to provide care for former employees who suffer health issues as a result of their service. This applies to NASA astronauts, and should apply to anyone that NASA sponsors for spaceflight, including payload specialists.

- a. Although NASA strives to make spaceflight as safe as possible, it is inherently dangerous. As a nation, we have concluded that the importance of space exploration justifies accepting some level of risk. There are current processes through the Department of Labor and the VA to provide treatment for federal employees and service members who require treatment for conditions related to their service. How are these processes insufficient?

The processes mentioned in the question are sufficient, though inefficient, in responding to the moral and ethical obligations addressed in response #4. The inefficiency stems from the highly specialized nature of the occupational hazards

faced by astronauts, with which: a) very few health providers familiar; and b) Department of Labor or Veterans' Affairs program administrators have virtually no experience. This inefficiency places an undue burden on a former astronaut seeking treatment through these processes. More importantly, if procured through these processes, such monitoring, diagnosis and treatment would likely occur without NASA's involvement, and thus result in the loss of medical information that would be of great use to clinicians and researchers working to better understand the medical impact of spaceflight to help enable future exploration.

6. The National Academies of Sciences has recommended that NASA take a page from military retirement policy and assume responsibility for the lifelong healthcare of former astronauts. Do you agree or disagree? And why? How should this responsibility affect existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits)?

I fully support the National Academies' recommendation. We simply do not have enough information on the tiny population of flown astronauts to paint a comprehensive picture of the health risks associated with spaceflight. It is incumbent on researchers and clinicians to not only probe as deeply as possible the medical issues that are known or even suspected to be associated with spaceflight, but also to look diligently for latent or difficult to detect effects that might have bearing on future human space exploration. The data associated with comprehensive health care for all former astronauts would be of great benefit to the future of human exploration of space. I'm not qualified to recommend how to interleave this increased responsibility with the existing benefits mentioned in the question, but one obvious possibility is to consider one benefit to be "primary" (in terms of cost accounting), and another could be "secondary." An example of this is that the NASA-provided benefit could be secondary to TRICARE for retired military members, and NASA would be responsible for the co-pay and deductible for which retirees often acquire secondary insurance.

7. Would NASA acceptance of the obligation to treat the long-term medical consequences of spaceflight affect the discussions that NASA has with its astronauts about risk, mitigation, and the willingness to accept risk? Would this long-term obligation for astronaut health care end up making NASA less risk tolerant? Or would the establishment of this long-term obligation make both NASA and its astronaut corps more willing to accept the health risks of human spaceflight?

I don't think acceptance of the obligation to treat medical consequences of spaceflight would materially affect NASA's risk posture; the amount of money in play is just too small when compared to the \$8.5B budget for Human Exploration and Operations. Although most astronauts don't make decisions about health risk based on who will pay for their medical treatment, it is likely that NASA assumption of the financial responsibility would have a positive effect on a few.

8. Retired civilian NASA astronauts, as former federal employees, are currently able to claim workers' compensation under the Federal Employees' Compensation Act (FECA). Receiving awards under FECA requires a determination that the injury or illness claimed was associated with federal work. Given that some health effects of spaceflight, such as cancer from radiation, do not appear until years after spaceflight has ended, do astronauts have difficulty proving cause under FECA? Are you more

comfortable allowing the NASA Administrator discretion to determine whether a condition was caused space flight, or an independent body as is currently structured under FECA for former federal employees?

As stated in my oral testimony, I am fully confident in NASA's ability to properly assess whether a health condition was incurred as a result of spaceflight, as well as in their objectivity in doing so. Further, an independent body structured under FECA would almost certainly lack the expertise possessed by NASA to make such a determination.

9. Civilian federal employees, including civilian astronauts, may be eligible for treatment and/or compensation under the Federal Employee Compensation Act (FECA) if they (or their survivors) can demonstrate an employment-related illness, injury, or death. To what extent could FECA, or modifications to FECA, meet the lifetime needs of astronauts for diagnosis and treatment of service-related health conditions?
I have no knowledge of anyone in the ASE-USA membership who has used or is familiar with the FECA-related treatment or compensation option. As such, it would be inappropriate for me to respond to this question.

10. Should the provision of monitoring, diagnosis, and treatment of retired or management astronaut spaceflight-related injury or disease be conditioned on participants agreeing to share their health data with NASA for scientific purposes? Or should NASA provide this services without condition, allowing the astronauts to decide whether or not, and in what capacity, their data is shared for scientific purposes?

The ability of NASA to use medical data obtained during monitoring, diagnosis and treatment of astronaut spaceflight-related injury or disease, as well as any data gathered through comprehensive health care, for not only scientific, but also operational purposes, is a key underpinning of the rationale behind such provision by the government (the ethical obligation notwithstanding). I therefore do think that such care should be conditioned on the agreement of the participant to share such data.

11. A 2014 report by the National Academies brings up ethical issues associated with releasing sensitive health information. It is the right of an individual to maintain the privacy of his or her medical information. However, in the case of retired astronauts, that very information can be used to protect the health of future astronauts. As astronauts what are your feelings about this issue? What is the general sense in the astronaut community about this dilemma?

The willingness to share medical data for research purposes varies widely among astronauts. It is understood that in some cases, due to the very small sample size, it is difficult to completely sanitize these data. The general feeling is that all reasonable measures should be – and are – taken by NASA to occlude the identity of the participants in a study or experiment, but that there may be cases where this is difficult or impossible. In my experience, such situations are discussed with the Principal Investigator during the informed consent process. Participation in studies is voluntary.

House Committee on Science, Space and Technology
Subcommittee on Space

*Human Spaceflight Ethics and Obligations: Options for Monitoring, Diagnosing and Treating
Former Astronauts*

Captain Michael Lopez-Alegria (USN, Ret.), President, Association of Space Explorers-USA
Former Astronaut, NASA

Responses to questions from Rep. Donna F. Edwards, Ranking Member

1. 1. In the summary of your prepared statement, you say that “*there is a private right to understand the comprehensive effects of spaceflight on human health as the democratization of access to space becomes a reality with the successes of commercial human spaceflight.*”
 - a. How specifically would expanded surveillance, diagnosis, and treatment better inform future private citizens seeking to go to space?
 - b. Would this require NASA to share data with citizens, private sector companies, and regulators such as the FAA?
 - c. Should FAA make the information a mandatory part of any Informed Consent Notification?
 - a. Data from expanded surveillance, diagnosis and treatment of spaceflight-related injury and disease will be used to inform future private citizens seeking to go to space through the publication of research by NASA and other Principal Investigators. To date, all orbital commercial spaceflight participants (SFP) have engaged flight surgeons to advise them during training and monitor them during spaceflight, and commercial companies looking to conduct suborbital flights likewise have medical personnel on staff. It is incumbent upon these providers to seek as much information as possible, both through the scientific literature and through professional education and conferences, etc.
 - b. Properly sanitized, non-attributable medical data obtained from provision of the aforementioned medical services should be provided to the taxpayer.
 - c. In the current construct the FAA should not mandate the inclusion of such data in the informed consent process. The lack of a requirement should in no way preclude the SFP, or their medical advisor, from obtaining as much information on health risks associated with spaceflight from the public domain as possible.
2. With regards to ensuring that the identity of individual astronauts is protected when making their health data available to researchers, are you satisfied with the steps NASA has taken to protect the privacy of its astronauts? If not, what additional steps should NASA take to protect privacy under the legislative proposal?

I am quite satisfied with the steps that NASA takes to protect the identity of astronauts that participate in medical studies and experiments. Please see my response to question 11 from Chairman Babin on this topic.

*Responses by Dr. Jeffrey Kahn***Responses from Dr. Jeffrey Kahn****Questions submitted by Representative Babin:**

1. In 2004, the National Academies' *Review of NASA's Longitudinal Study of Astronaut Health* stated that it would be difficult to discern whether or not an injury or disease exhibited later in life is actually related to spaceflight. The report cites cataracts as an example. Because of this, the report also concludes that NASA should pay for all of an astronaut's health care needs. Should we view a decision to cover all medical issues as a temporary measure? As time goes on we will understand more about the effects of space and be able to accurately determine if an issue is related to spaceflight?

Although some uncertainty may resolve as greater numbers of people are involved in spaceflight for longer periods of time, the total number of individuals is likely to remain small for the foreseeable future. We know from terrestrial medicine that even when studies involve populations of thousands of individuals, causality can be extremely difficult to establish. The second problem is that some health problems may only become manifest after years have passed. Thus, although some uncertainties may be resolved in the upcoming decades, it would be likely that proving causality for all potential health conditions will not be possible for any time in the foreseeable future.

In addition, given the relatively few opportunities to for humans to spend time in space, the committee believed that it is imperative that as much as possible be learned from that experience to apply to protection and care for future astronauts and to continue to improve risk mitigation and treatment efforts. The monitoring and treatment over the course of an astronaut's lifetime will enable a learning healthcare approach and maximize risk reduction efforts over time.

2. Is there an ethical obligation to provide for the monitoring, diagnosis and treatment of retired astronaut spaceflight-related injury or disease? If so, does the government's obligation apply without qualification of service? For example, should it extend to payload specialists?
 - a. Although NASA strives to make spaceflight as safe as possible, it is inherently dangerous. As a nation, we have concluded that the importance of space exploration justifies accepting some level of risk. There are current processes through the Department of Labor and the VA to provide treatment for federal employees and service members who require treatment for conditions related to their service. How are these processes insufficient?

The ethical obligation as stated in the National Academies' reports is for the government to provide for the monitoring, diagnosis, and treatment of all of those who serve and have served in space. For the purpose of the report, the committee used the terms "astronauts" and "crew members" interchangeably.

The current VA and DoL processes, as I understand them, require a service-connection between the health condition and an exposure or other connection to service. As noted above, the data are not available (nor will they likely be in the foreseeable future) to establish service-connection for space-related exposures/experiences. In addition, systems that require connection between health condition and service could limit the data available for learning about the health experiences and health outcomes of space flight as they would not provide the level of detail and follow-up on all who have served in space.

3. The National Academies of Sciences has recommended that NASA take a page from military retirement policy and assume responsibility for the lifelong healthcare of former astronauts. Do you agree or disagree? And why? How should this responsibility affect existing benefits offered to retired military personnel (Tricare), former service members (Department of Veterans Affairs benefits), and former government employees (Department of Labor benefits)?

As the chair of the Academies' committee, I support the study's recommendations that it is the government's ethical responsibility to provide lifelong healthcare of astronauts. The details would need to be worked out regarding how that would affect existing DoD, VA, or DoL benefits. The committee was tasked with developing an ethical framework but was not asked to address the specifics of implementation of such healthcare coverage.

4. The 2014 National Academy of Sciences study that you chaired recommended that NASA should provide lifetime healthcare for astronauts. What are the most important characteristics of the lifetime healthcare that your study recommended? And how would the care your study recommended differ from what is currently provided, either directly by NASA or through other programs such as employee and retiree health insurance?

The report emphasized six ethical responsibilities that the nation has to astronauts involved in long duration and exploration spaceflight: avoid harm, beneficence – ensuring the benefits of a specific mission, favorable balance of risk and benefit, respect for autonomy, fairness, and fidelity. We did not get into the specifics of the characteristics of long-term health care other than to state that “the [ethical] principles support the minimization of risk of harm, the treatment of injuries or health conditions during the flight, and the ongoing monitoring and provision of health care after the flight. This binding duty to provide ongoing surveillance, monitoring, and health care during the lifetime of the astronaut is part of the continuum of risk management that begins with engineering and design efforts to minimize risk and continues through the flight and postflight.” (p. 127)

Currently there is no coordinated care or monitoring provided other than the Longitudinal Study of Astronaut Health, which is an optional program.

5. Why did your study conclude that existing astronaut health benefits are insufficient? Did your committee hear from any former astronauts that they were not receiving sufficient treatment for conditions caused by their federal service? To what extent do your study's recommendations differ, depending on whether an astronaut is a civilian or a military officer?

As noted above, the charge to the committee was to focus on an ethical framework and the principle of fidelity was one part of that framework. The committee had two former astronauts on the committee and the committee heard from others but did not examine the issues of specific coverage. The committee's recommendations did not differentiate between civilians and members of the military as the focus was on the broader concepts of ensuring coverage and learning from all individuals who participate in spaceflight.

6. Would NASA acceptance of the obligation to treat the long-term medical consequences of spaceflight affect the discussions that NASA has with its astronauts about risk, mitigation, and the willingness to accept risk? Would this long-term obligation for astronaut health care end up making NASA less risk tolerant? Or would the establishment of this long-term obligation make both NASA and its astronaut corps more willing to accept the health risks of human spaceflight?

It was my perception during the course of the Academies' study that NASA goes to great efforts to address risk from multiple perspectives and that astronauts are made fully aware of the risks. Crew members appreciate the real and immediate risks they face at launch and throughout spaceflight, so health outcomes are only one of the

many risks they accept. It was the committee's conclusion that establishing a long-term commitment to astronaut health would affirm the nation's commitment to these individuals who accept significant risks on behalf of all of us.

7. Retired civilian NASA astronauts, as former federal employees, are currently able to claim workers' compensation under the Federal Employees' Compensation Act (FECA). Receiving awards under FECA requires a determination that the injury or illness claimed was associated with federal work. Given that some health effects of spaceflight, such as cancer from radiation, do not appear until years after spaceflight has ended, do astronauts have difficulty proving cause under FECA?

The committee did not look at specific programs such as FECA. The latency of some health concerns would be one issue if the program for astronaut health care was based on service connection and the many unknown risks would be another. The committee recommended a comprehensive commitment to healthcare that was not based on establishing a service connection.

8. If the Department of Labor relies on NASA for subject matter expertise to determine if spaceflight contributed, precipitated, accelerated, or aggravated a health problem purportedly connected to an occupational hazard, why is it necessary to give NASA new authority? Doesn't NASA already play a significant role in the existing process?

This is not a matter that the committee considered, nor do I have personal expertise to speak to this question.

9. Civilian federal employees, including civilian astronauts, may be eligible for treatment and/or compensation under the Federal Employee Compensation Act (FECA) if they (or their survivors) can demonstrate an employment-related illness, injury, or death. To what extent could FECA, or modifications to FECA, meet the lifetime needs of astronauts for diagnosis and treatment of service-related health conditions?
 - a. If Congress chose to take this approach, what changes to FECA would you recommend to accommodate the unique circumstances of astronauts and the unique occupational exposures they receive in space?
 - b. If Congress made changes to FECA in order to meet the occupational healthcare needs of civilian astronauts, what issues would remain for astronauts who are military service members?

The committee did not look at specific compensation programs. FECA would require service-connection and due to the many unknowns regarding space-related risks and health outcomes, the committee believed that comprehensive lifetime health care to astronauts—in which there was no need to prove service connection—is the nation's ethical responsibility.

Questions submitted by Representative Donna F. Edwards:

1. During the hearing, Captain Kelly suggested that options to mitigate the dangerous effects of radiation on a crew travelling to Mars and back were limited to either making the trip faster using new propulsion technologies or adding more shielding—an option that would require greater mass. I understand that the National Academies panel you chaired in 2014 addressed issues associated with changing the standards that establish the amount of radiation to which crew

members can be subjected. Can you summarize your panel's findings and comment on whether changing radiation standards is a third option NASA could consider?

The study looked at radiation standards, as one of the key questions posed to the committee was how should NASA make decisions when the risks are unknown and/or could exceed the current exposure standards. Radiation is one of the major concerns although other potential health outcomes including bone loss, loss of visual acuity, and change in muscle mass are also known concerns.

Radiation exposure is a complex topic particularly regarding galactic cosmic radiation where so little is known. The committee considered options regarding standards (including radiation standards) and found that changing the radiation standards was ethically unacceptable. The report states (pp. 142-143),

"If a human spaceflight mission cannot meet current health standards, or if inadequate information exists to revise a health standard, the options, as identified and examined by the committee, would be to: (1) liberalize the NASA health standards, (2) establish more permissive "long duration and exploration health standards," or (3) grant an exception to the standard in order to conduct these missions before new protective technologies and strategies are available or additional data are acquired which may allow revision of the standard. The committee found the first two options to be unacceptable when evaluated against the ethics principles and responsibilities described in this report.

The committee finds relaxing (or liberalizing) current health standards to allow for specific long duration and exploration missions to be ethically unacceptable. Current NASA policy outlines the administrative processes and levels of approval required to initiate a new health standard or revise a current health standard. NASA's health standards "are based on the best available scientific and clinical evidence, as well as operational experience" (NASA, 2007, p. 8). Moreover, review of health standards occurs every 5 years or can be triggered any time that new research data or clinical observations indicate an update may be necessary. Modifying health standards outside of this established process merely to permit long duration and exploration missions would be arbitrary.

The second option maintains current health standards for all missions except long duration and exploration spaceflight, which would have a separate set of health standards. This approach presumably would entail setting a more permissive ceiling on allowable risk for long duration and exploration missions under conditions in which existing evidence and knowledge make it nearly impossible to quantify those ceilings. The committee found this approach wanting, lacking a clear and compelling justification for why acceptable risks and levels of uncertainty should be greater for long duration and exploration missions than other human spaceflight missions.

Having excluded the options of modifying existing standards or creating a separate set of standards, the committee concludes that the only ethically acceptable option that could allow for increased risk exposures in the context of long duration and exploration spaceflights is granting an exception to existing health standards. The committee believes that exceptions to health standards should be considered on a mission-by-mission basis and used under very limited circumstances following the ethics-based decision framework recommended."

2. How should Congress ensure that any astronaut healthcare program that may be established reflects the ethical principles articulated in your Committee's report?

The committee provided its recommendations as a potential framework for ethically

acceptable decisions regarding health risks and long duration and exploration spaceflight. The framework is not specific to an astronaut health care program but does outline ethical principles and responsibilities for three levels of decision making for: 1) missions that fail to meet the health standards, 2) specific mission scenarios and objectives, and 3) crew selection and astronaut participation.

3. In the summary of his prepared statement, Captain Lopez-Alegria says that *"there is a private right to understand the comprehensive effects of spaceflight on human health as the democratization of access to space becomes a reality with the successes of commercial human spaceflight."*
 - a. Do you agree with his view that expanded surveillance, diagnosis, and treatment better inform future private citizens seeking to go to space?
 - b. Do you have any concerns associated with NASA being required to share astronaut health data with citizens, private sector companies, and regulators such as the FAA?

The committee's discussion regarding increased knowledge about the health impacts of space travel support a view that opportunities to expand surveillance, diagnosis, and treatment could inform commercial spaceflight.

Data sharing issues were a concern addressed by the committee as informational risks that need careful attention. The committee stated (p. 122-123): "Concerning informational risks, data on astronauts' health, both during and following missions, are potentially valuable resources for multiple purposes, including continuous learning about health risks (e.g., refining future health and safety standards for the benefit of future crews), internal assessment and quality improvement activities, and promoting transparency and public trust through evidence-based policies and decisions. Because there is only a small sample of participating astronauts, however, commonly used strategies for protecting individual privacy (e.g., de-identifying data) may not be effective. Even if overt identifiers are stripped, the data may be intrinsically identifiable if, for example, only two men were on a mission and two cases of post-mission prostate cancer were reported. Long-duration and exploration spaceflights present opportunities where access to health data can support activities with very high social value, but where privacy may be particularly difficult to protect. It is in the interest of current and future astronaut crews to enable appropriate uses of astronaut health data to aid continuous learning and improvement of safety standards and risk-mitigation strategies. However, stringent policies to protect the privacy and confidentiality of sensitive individual health information are an essential precondition for such activities."