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INTERVIEW OF
DR. RONALD TURNER
ANALYTIC SERVICES, INC.

Conducted by Troy Cline

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1 P R O C E E D I N G S

2 MR. CLINE: All right. Well, Ron, thank you
3 so much for your time today. It's exciting to be here
4 and to already be talking with you about some of your
5 interests and research. Could you tell us exactly who
6 you are and what you do now and your interest in space
7 weather?

8 DR. TURNER: Okay. I'm Ron Turner. I'm
9 officially designated a Fellow of Analytic Services,
10 or ANSER, a not-for-profit company in the Washington,
11 D.C. area. So we provide support to the government on
12 a variety of issues, and I've been with this company
13 for about 28 years. And a good chunk of that time has
14 been spent in the area of space weather, actually. I
15 primarily work lately in the area of risk management
16 strategies for astronauts that are exposed to the
17 space radiation environment. So that's the main area
18 that I focus on.

19 In the last several years, I've started to
20 get interested in the broader topic of severe space
21 weather and the impact that it might have on the
22 nation and the nation's infrastructure. You've

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1 probably heard that a severe space weather event could
2 potentially knock the power grid off, and it could be
3 down for anywhere from weeks to months, and that, of
4 course, would sort of ruin your day.

5 Our company does a lot of work in homeland
6 security, and so I've got some training in things like
7 national response policy and stuff. And so in the
8 last few years, I've applied my understanding of how
9 we -- how the nation responds to significant events to
10 how the nation would respond to a significant space
11 weather event. So it sort of grew out of risk
12 management -- you know, a very narrow topic, which is
13 risk management strategies for astronauts, to a
14 broader topic, which is how the nation responds to
15 severe space weather events.

16 MR. CLINE: Now, that basically answers the
17 question of what is your primary research interest, or
18 is there more to what you'd like to say about that
19 particular ...

20 DR. TURNER: No, I think that's basically my
21 research interest.

22 MR. CLINE: And I'm very interested in

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1 hearing more about, when you're talking about risk
2 management for astronauts in space, because many
3 people have asked questions about with our future of
4 going into space, potentially going back to the moon,
5 potentially going to Mars and beyond. Right now, most
6 of our understandings that people have been telling me
7 is that we don't really have the ability to go for
8 six, seven, eight, nine months or a few years in space
9 without lethal doses of radiation. Is that true, and
10 how could we protect ourselves?

11 DR. TURNER: Okay. Well, yeah, radiation is
12 one of the key issues for a long-duration space
13 flight. It's long been recognized by NASA that
14 countering this radiation threat's going to be
15 critical to doing any long-duration space mission,
16 whether you're going to Mars, which might take up to
17 two to three years, or if you're even going out to
18 some -- any deep space location, on the moon, maybe,
19 even, for six to nine months or a year. So you've got
20 to -- you definitely need to worry about the space
21 radiation impacts on the astronaut.

22 There's two broad things that space

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1 radiation can do to astronauts, and they're from two
2 distinct sources. You've got the really major events,
3 like a space weather storm, a solar storm that creates
4 a solar particle event, and then you have several
5 days, maybe, of really intense radiation that an
6 astronaut could potentially be exposed to.

7 Then you also have the steady background
8 drizzle of space radiation called the galactic cosmic
9 radiation. Now, the galactic cosmic radiation is
10 there all the time, but at lower doses. The
11 difference between -- another key difference between
12 the two is the GCR is really highly penetrating, so
13 there's not very much you can do to shield against it,
14 and it builds up over time throughout the mission.

15 The solar storms, if the space weather
16 community comes through with what it needs to do,
17 which is to provide adequate warning that a solar
18 storm is either imminent or one is ongoing and has the
19 potential to last for a long time, that space weather
20 warning goes to the operators. The operators get the
21 astronauts into shelter, and solar storms can be
22 shielded with relatively modest equipment --

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1 relatively modest habitats. You can shield a space
2 radiation event with relatively modest shielding.

3 And so it's really difficult for one of
4 these space weather storms to actually be lethal,
5 okay, or even reach the point of causing space weather
6 sickness if you've got a system in place for warning
7 the astronaut that the event is underway. They have
8 one to three hours, even, to get under shelter and
9 still not get a critical acute dose. So as long as
10 the space weather community is involved in the
11 planning of these missions, then that's a manageable
12 issue.

13 The other extreme, which causes more
14 consternation for the mission planners for these long-
15 duration missions, especially a mission to Mars, is
16 the GCR.

17 MR. CLINE: And GCR stands for ...

18 DR. TURNER: Galactic cosmic radiation.
19 Galactic cosmic ray, radiation. The GCR is the
20 component that I was talking about that's highly
21 penetrating, but a very low -- very, very low dose
22 rate (ph). It just builds up over time.

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7

1 So with nominal shielding on a habitat or a
2 spacecraft, you can provide some level of protection
3 to the astronaut inside that vehicle, doubling the
4 shielding, which more than doubles, say, the mass of
5 this vehicle, which is prohibitive from a system
6 architecture point of view, only reduces that dose by
7 about maybe 20 percent. So adding mass, adding
8 shielding is not an effective way to mitigate the GCR
9 threat.

10 Now, what is the GCR threat? Well, the GCR
11 threat -- one of the known things that the GCR can do
12 to the astronaut, that deep space radiation can do to
13 the astronaut, is increase the probability that
14 sometime in life, they will develop cancer. Okay? So
15 it's not an immediate mission threat, it's a lifetime
16 threat to the astronaut, which, in many ways, is just
17 as important as the mission itself, because you don't
18 want to put the astronaut out there in harm's way with
19 all the mission-level risks, which are already high,
20 get the astronaut safely back to Earth, only to have
21 him or her undergo, you know, severe health problems
22 for the rest of their life. So you still want to

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1 minimize the long-term health effects to these
2 astronauts.

3 Where we might have some room in helping the
4 mission planners is it's not likely that the GCR dose
5 would ever be lethal during the course of a mission.
6 In fact, NASA's current permissible exposure levels
7 limit the astronauts to a risk that's no more than
8 3 percent excess probability of getting cancer in
9 their lifetime. The catch is that the NASA limit is
10 at the 95 percent confidence interval; that is,
11 there's a 95 percent chance that the exposure that
12 they get will not cause their risk of cancer to be
13 3 percent for the rest of -- an additional 3 percent
14 for the rest of their life.

15 And that uncertainty, the 95 percent
16 uncertainty, keeping the limit inside that 95 percent
17 uncertainty, that's what limits the days in deep space
18 to 150 to maybe 220 days. It's -- it depends on the
19 astronaut's age, it depends on the astronaut's gender.
20 So, you know, female astronauts are more susceptible
21 to deep space radiation than male astronauts. So
22 there's a -- and younger astronauts are more

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9

1 susceptible because they have a longer lifetime ahead
2 of them for the cancer to develop. Okay? So if you
3 want to keep the astronaut risk at 3 percent at the 95
4 percent confidence, then you have to severely limit
5 their time in deep space.

6 So the question is are those the right
7 guidelines? You know, is that really the right level
8 of protection that we need to impose on the mission
9 planners? Is an additional 3 percent risk of cancer
10 the right number, given all the other risks that the
11 astronauts were already posed -- already faced with?
12 Is the 95 percent confidence interval overly
13 conservative? Can we, you know, reduce that
14 confidence interval?

15 Those questions, actually, are being
16 addressed by a National Academy committee under the
17 Institute of Medicine, and I am on that committee, so
18 I, you know -- that report is due out in the March
19 timeframe, and we're going to be going back to NASA
20 with some recommendations on the framework that they
21 could use to understand what level of risk is
22 appropriate for health risks that are -- that have a

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10

1 large degree of uncertainty, and the committee's
2 responsibility is to look at more than just the
3 radiation risk, because there's a lot of health risks
4 that we don't understand all the impacts on that the
5 astronauts are going to be exposed to when they go on
6 these deep space missions.

7 MR. CLINE: You know, what's very
8 interesting, I just conducted an interview with
9 astronaut Dr. Phillips, who had been at the
10 International Space Station for about six months, and
11 he said he received -- of course, when he came back,
12 they do the testing to find out how much radiation
13 you've been exposed to and so forth.

14 And he said he was at a particular level
15 that wasn't alarming, but it was still something he
16 wanted to pay attention to, but he said what's
17 interesting is over half -- or about half of the
18 dosage of radiation that he received wasn't in space,
19 it was during the testing phases of getting ready --

20 DR. TURNER: That's right.

21 MR. CLINE: -- to go.

22 DR. TURNER: That's right. There's a --

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11

1 there -- when they -- when NASA looks at the radiation
2 exposure to an astronaut to determine whether they can
3 fly the next mission, for example, they don't just
4 look at the dosimeter that the astronaut wore on the
5 last space flight and the one before that. They do
6 look at the medical exams he's been under, he or she's
7 had. They look at their -- the -- all the radiation
8 history that they have access to, which is quite a
9 bit.

10 So, yeah, and we're reaching a point where
11 the 3 percent limit, even though you -- even though no
12 astronaut has come close to the 3 percent limit on an
13 International Space Station mission and is -- they're
14 not likely to under any one space mission, they're
15 reaching the point where, as they look at longer stays
16 on the space station, there are some astronauts that
17 come close to those limits, and so they're not -- you
18 know, they're sort of precluded from being selected
19 for those missions.

20 So that gets the astronauts' attention a lot
21 -- the Astronaut Office attention quite a bit, when
22 they realize that some of their members may be not

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12

1 permitted to do a mission that they would love to
2 train for because they're potentially up against these
3 radiation limits. So it's a very serious issue, even
4 in the era of space station, and it's going to be even
5 more important when we start doing these deep space
6 missions, or if we choose to go back to the moon
7 someday.

8 MR. CLINE: Now, what is also interesting
9 for listeners to understand and hear about again is
10 the reason that, on Earth, we are relatively safe from
11 most of these radiations that we're talking about
12 right now. It's because of our magnetic field and
13 atmosphere?

14 DR. TURNER: And atmosphere. The
15 atmosphere's a big chunk of it -- is a big part of it.
16 The magnetic field goes a long way toward mitigating
17 the galactic cosmic rays. The atmosphere finishes it
18 off, finishes off that protection.

19 So we have, in the -- I'm trying to --
20 trying to come up with numbers that -- that -- that
21 mean more than a thousand grams per cubic centimeter.
22 Say a water equivalent thickness of protection would

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13

1 be about -- I don't know. I've got to convert a
2 thousand --

3 MR. CLINE: Uh-huh.

4 DR. TURNER: -- in realtime, a thousand
5 grams per centimeter squared into a distance, which
6 is, I guess, about ten meters --

7 MR. CLINE: Uh-huh.

8 DR. TURNER: -- of thickness. So we've got
9 the equivalent of ten meters -- I'll check this
10 number, but I think we've got the equivalent of ten
11 meter water thickness, you know, protecting us from
12 the galactic cosmic rays. You're not going to put a
13 ten meter wall around the astronauts all the time.
14 Even that seems a little short. It may be even
15 thicker than that, a thousand grams per centimeter
16 squared of water -- of thickness between us and the
17 (inaudible).

18 MR. CLINE: So essentially making a
19 spacecraft out of water in a way to --

20 DR. TURNER: Well, out of material, lossy
21 (ph) material that's very, very thick. And, actually,
22 even the thickness of the atmosphere doesn't count,

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14

1 because that's the narrow -- that's straight up.

2 Okay? We actually get protection, you know, both from
3 the ground below us and all the thicker angles that
4 the radiation has to come through from -- you know,
5 oblique angles from outside space.

6 So we've got a -- the short answer is we've
7 got a tremendous amount of shielding above us right
8 now, and we still get radiation. The background
9 radiation, there is still a significant component of
10 our natural background radiation that comes from
11 cosmic rays. Okay? Our day-to-day life, we still get
12 a significant amount of background -- a significant
13 fraction of our daily background radiation comes from
14 cosmic rays, even with all that shielding. So take
15 away that shielding, and now the astronauts' exposure
16 goes way up.

17 MR. CLINE: Now, in your experience -- I've
18 heard many people talk about the Apollo missions that
19 have gone to the moon before and that we were very
20 fortunate when those missions launched. There was
21 some information, of course, and knowledge about space
22 weather at that point, not like we have now, but that

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15

1 we actually, at times, went up between storms and the
2 -- had the astronauts been in space during a powerful
3 storm, that could have been a different story.

4 DR. TURNER: All right. We had -- we had a
5 double challenge in the -- in the Apollo era that we
6 got lucky. One was we didn't go during a major storm,
7 like you just said. In fact, between two Apollo
8 missions, one of the -- there was one of the most
9 severe space weather events that we have on record.

10 An August 1972 event is one of the ones that
11 we still measure other storms against in terms of
12 severity. So one of the biggest storms we --
13 radiation storms that we've had occurred between two
14 Apollo missions.

15 So the other challenge that increased the
16 risk was the actual lander -- the Apollo lunar lander
17 had a very thin shield, a very thin -- very thin
18 walls, the lunar lander, very -- you know, not a whole
19 lot more than what you would get from a spacesuit
20 anyway. And so had that storm happened while the
21 astronauts were on the lunar surface, especially if
22 they had been off some distance from the Lunar Module,

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16

1 so they had to get back to the module and then get
2 back and rendezvous with the Command/Service Module
3 before they could, you know, really get safe.

4 The Command/Service Module had a fairly
5 robust amount of shielding associated -- well, the one
6 -- the piece that was in orbit around the moon and the
7 piece that they came back in had a lot of shielding
8 from radiation storms, but the lunar lander, you know,
9 had very thin walls and would have been very
10 susceptible to a solar storm.

11 And so in a way, we got lucky, but, you
12 know, you can still play the odds. A storm is about
13 two -- the severe part of a storm is probably two
14 days, at worst, a week, and so you put that one week
15 against all the one-week landing opportunities in one
16 year, and the odds still go down. So it wasn't that
17 miraculous that we got lucky -- that we, you know,
18 survived, but it still was a -- it still was a threat
19 that -- and one of the chances that we took.

20 (Off the record.)

21 MR. CLINE: Can you tell us a little bit
22 more about with what and when you were involved in

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17

1 space weather research?

2 DR. TURNER: Okay, sure. Well, I got my PhD
3 in physics in 1984, Ohio State University, in nuclear
4 and particle physics, not at all space weather. Okay?
5 Of course, I grew up in Florida in the Space Coast,
6 where my father actually was a technician associated
7 with the Apollo missions.

8 So every day at dinner, he'd come home, and
9 he'd tell us, you know, these stories about this,
10 that, and the other that just happened, you know, when
11 he was working on the Apollo -- working with the
12 Apollo Command Module that day. Okay. So it was
13 cool. Okay? It was awesomely cool growing up, you
14 know, with the space program evolving and having a
15 personal connection to it.

16 So I was -- even though my academic interest
17 at the time, even as a kid, started to go into the
18 area of physics and nuclear and particle physics,
19 because that was exotic, cool stuff too, okay, I still
20 carried with me this fascination with the Human Space
21 program.

22 Okay. So fast-forward to about 1984, when I

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18

1 get my PhD, and I start working for this company,
2 ANSER, Analytic Services, and Analytic Services is
3 supporting the Air Force with a whole variety of space
4 programs, and I get -- I am, fortunately to me,
5 assigned to support the Air Force weather satellite
6 program, which is a low-altitude weather satellite
7 that helps the -- that would help the Defense
8 Department with Air Force operations.

9 Well, the weather satellite carried space
10 weather instruments on it, and being a physicist and
11 liking the space program, I taught myself about what
12 these space weather instruments were doing and what
13 they were -- you know, what -- you know, why they kept
14 these space weather -- so-called space weather
15 instruments on their satellite that was supposed to be
16 looking at terrestrial weather, you know?

17 So I got fascinated with that. Well, we
18 also -- our company also helped this thing called the
19 space -- the Department of Defense Space Test Program,
20 and the Space Test Program flew research missions that
21 tried to get a better understanding of space weather.

22 The panel that would decide what instrument

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19

1 would fly next was usually made up of a bunch of
2 colonels that were operators and weren't physicists,
3 and so they didn't really understand the nuances of
4 the research world when the researchers would come in,
5 and they'd say, "I've got this experiment. It's
6 looking at space weather. It's going to help you
7 communicate better because we solved the communication
8 problem." Okay? They all sounded the same to the
9 colonel board.

10 So ANSER asked me to put together sort of an
11 introduction briefing before they do their space
12 weather briefs from the experimenters, just to give
13 the panel an overview of what space weather is and
14 what the different experiments were trying to
15 accomplish and how the different experiments were
16 actually different from one another, trying to
17 accomplish different things; where there was overlap,
18 where there wasn't.

19 And, of course, my job wasn't to try to tell
20 them which ones were good or bad, it was just to tell
21 them, you know, "This is a level playing field. This
22 is what all these instruments do." And that was

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1 really cool because it gave me the chance to get to
2 know the space weather researchers, especially on the
3 DoD side. Okay?

4 So I got to know a lot of the scientists
5 that were doing space weather for the Air Force and
6 the Department of Defense, and I got to know a little
7 bit about what they were trying to do, and I always
8 had to keep an operational view on what they were
9 doing.

10 So when they told me about all the cool
11 stuff they were doing, I had to think, "Okay. That's
12 all really cool. I'm a physicist. I think that's a
13 lot of fun. But why is the Air Force going to care?"
14 Okay? "What does this mean to them in an operational
15 sense that would cause them to want to continue your
16 funding?" So I had to -- even at the beginning, I had
17 to keep this dual hat on, the research hat and the
18 applications hat, so I was the filter between the
19 scientists and the operators giving these briefs.

20 Well, that was cool, but added to that was I
21 still had this interest in the Human Space Flight
22 program. So the whole time, I would think, "Is there

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21

1 anything I can do with this knowledge to start working
2 for NASA in some way?" And in the early '90s, I did
3 go over to NASA, literally knocking on doors, people I
4 didn't know, just saying, "Hey, I have this fun
5 interest in the radiation risk problem to astronauts.
6 Do you care that I have this interest?"

7 And amazingly enough, I found somebody who
8 said, "Yeah, we do care," and that was the Human
9 Research Program that was studying the radiation risk
10 to astronauts. Mostly they were looking at the
11 biological side of the problem; you know, what does a
12 certain level of radiation do to a cell that makes it
13 eventually turn cancerous? Okay?

14 So they didn't have a lot of -- they had
15 physicists on board. They had the physicists who were
16 the accelerator people who knew transport of particles
17 through matter, but they didn't have anybody in their
18 little circle of researchers that was an expert on the
19 space weather side.

20 So NASA had their space weather people over
21 here, and they had their human effects people over
22 here, and they had their operations people somewhere

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22

1 way over there. Okay? Not really talking to one
2 another.

3 And I said, "Well, you know, I've already
4 got this experience of trying to be the interface
5 between the science community and the applications and
6 the operations community. Maybe I can apply that same
7 experience to you on the radiation risk problem and
8 start looking at risk management strategies from a
9 larger perspective."

10 And that's what caught NASA's eye, and lo
11 and behold, they did, in fact, fund me to start
12 working on that area, and that was thrilling for me.
13 And I benefited a whole lot from being able to go to
14 annual space weather conferences from the operational
15 people and also going to science conferences that the
16 National Science Foundation would fund.

17 So I'd go to talk to the scientists, and
18 they would know nothing about the biological side, so
19 they'd talk to me, and then I'd go to the biologists,
20 and I'd talk to them about the space weather side. So
21 I managed, you know, to be, again, just like I was for
22 the Air Force, sort of an interface between these

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23

1 different communities, and that was really, really
2 cool. So basically, I just kept adding to that, and
3 that's how I -- you know, that's how I got really
4 going in space weather.

5 Now, recently, I mentioned already that
6 because my area of expertise became radiation risk
7 management for astronauts, my company works in the
8 area of homeland security, and so I did broaden that
9 research area -- or that interest area into how one,
10 you know, applies national risk management strategies
11 against national effects of space weather. So that's
12 another area of interest that I've developed, and
13 that's slightly more recent.

14 MR. CLINE: When you talk about space
15 weather effects nationally, you're talking about
16 societal effects upon electrical grid systems, power ...

17 DR. TURNER: Yeah. We've been lucky that we
18 haven't had a -- sort of a super storm in space
19 weather in the last 50 years or more. Okay? We've
20 had severe storms, but we haven't had a super storm,
21 super storms like what happened in the mid-18 -- in
22 1856, this thing called the Carrington Event, which

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24

1 was a really super storm.

2 Obviously, in the 1850s, we didn't have
3 massive power grid problems, but we did have telegraph
4 lines that went from one city to another city, and
5 this storm, the Carrington Event storm, was so severe,
6 it coupled into these long transmission lines that
7 carried telegraph cables from one to another --
8 coupled into those lines and actually put enough
9 energy into those lines that it caused the telegraph
10 equipment to overheat and burn entire shacks down. I
11 mean, that's how much energy got dumped into the
12 system, and that's one, you know, very, you know,
13 simple system that had a -- that one of these super
14 storms interacted with.

15 So now we look at our society the way it is
16 today, and we ask, well, we've got power grids that,
17 you know -- that go across the country. We know that
18 there have been storms that haven't been as severe as
19 the Carrington Event, but they've been severe enough
20 to cause electrical grid disruption, melting power
21 transformers in Quebec and in South Africa, so it can
22 happen. We've got in existence proof that it can

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25

1 happen.

2 The question is, you know, how likely is it?
3 We don't know, because we don't know how often the
4 events like the Carrington storm are. Are they one in
5 500 year events? Are they one in a hundred year
6 events? We don't know. And we also don't know
7 exactly how a storm like that would play out locally,
8 you know, from the -- on the Earth on a local time
9 scale. So there's a lot we don't know about the
10 physics, but we're learning a lot. There's a lot of
11 research going on to try to quantify those effects.

12 My side of the problem doesn't have anything
13 to do with the physics, other than trying to keep up
14 with what the research area is. Rather, because our
15 company does a lot of homeland security work, I look
16 at what the national policy framework is, and how
17 would that national policy framework be invoked if we
18 had one of these large events or thought one of these
19 large events was pending? So that's been a really fun
20 area -- well, interesting area for the last few years.

21 (Off the record.)

22 MR. CLINE: Can you tell us some of the key

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26

1 events or a turning point in space weather research in
2 your experience?

3 DR. TURNER: Actually, that's an easy one
4 for me, because I think that there's one very, very
5 significant event that was a major milestone in making
6 space weather what it is today as a discipline, and
7 that was a number of years ago, when NASA first
8 started making data from one of their satellites
9 available in near realtime to the forecast community,
10 and that was the WIND spacecraft.

11 The WIND spacecraft was out there trying to
12 monitor, as the name implies, solar wind parameters,
13 parameters of the solar wind, and it had a number of
14 other observations that it made, but, again, mostly to
15 characterize the solar wind.

16 The solar wind gives us the background that
17 all the other space weather effects ride on top of, so
18 you need to know the solar wind conditions are in
19 order to estimate, you know, what the impacts might be
20 into the Earth.

21 So when NASA started making this wind data
22 available to the operational forecast community --

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27

1 NOAA in Boulder has a group that does the -- even then
2 did the routine national weather forecast. Well, it
3 revolutionized their ability to do realtime
4 forecasting, because they had a least a little bit of
5 data that was not just, you know, based on secondary
6 observations, but was one of the primary drivers.

7 They knew when the solar wind speed was
8 increasing, when the magnetic fields were increasing,
9 the interplanetary magnetic fields were increasing.
10 They had direct measures, more -- sort of like us now
11 not just, you know, wondering is the rain going to
12 increase tomorrow, but actually knowing that a hundred
13 miles away, a front is crossing, and then 50 miles
14 away, when did that weather front, you know, get there
15 so that now we could forecast when that weather
16 forecast was going to get to us.

17 By having this realtime data available from
18 WIND, we started to get a realtime sense of what the
19 space weather environment was. That led NASA to
20 expand that program because it was so effective. Now
21 we have data -- more and more data started to become
22 available in realtime to the operational community,

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28

1 including observations of the sun from the SOHO
2 spacecraft, even more precise data and more regular
3 data from the ACE spacecraft, and today we just rely
4 on those things.

5 SOHO has been replaced in realtime by the
6 Solar Dynamics Observatory, SDO, so there's still
7 realtime data on watching the sun, WIND data, which,
8 admittedly, even at the time, was spotty, because it
9 wasn't always there. There were periods when the wind
10 data -- when the WIND spacecraft wasn't where it
11 needed to be to give realtime warning to Earth.

12 But now we have the ACE spacecraft that is
13 in the right place to give the realtime warning. Of
14 course, the ACE spacecraft has been up for a very long
15 time, and we don't know how long it's going to last.
16 You know, there's a new spacecraft being planned to
17 take ACE's place, at least as an interim replacement,
18 to make some of the ACE measurements.

19 So that really revolutionized, to me, the
20 space weather community and being able to communicate
21 effectively to the public that this space weather
22 really is important. Look, this is the data that we

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1 just had.

2 The research community realized that there
3 was a lot of advantages to having this realtime data
4 stream available. It became a lot easier to get
5 access to realtime data, even if you weren't the
6 principal investigator of that instrument. So while
7 there was always a lot of good sharing of space
8 weather data, now the sharing was enhanced, was more
9 realtime, and you could test your own theory -- before
10 you went public, you know, you could -- back in your
11 own lab, you could test, well, did that really work or
12 not? It didn't work. Let's tweak the parameters.
13 Ah, now it's starting to work a little bit.

14 Things like the Community Coordinated
15 Modeling Center at Goddard were implemented to enhance
16 this modeling community and what it did. So, really
17 -- and I think a whole lot of that -- a lot of the
18 impetus for that was when NASA started making realtime
19 data available to the operational community.

20 (Whereupon, the interview of Dr. Ronald
21 Turner was concluded.)

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CERTIFICATE OF TRANSCRIPTION

I, MARY E. YOUNG, hereby certify that I am not
the Court Reporter who reported the following
proceeding and that I have typed the transcript of
this proceeding using the Court Reporter's notes and
recordings. The foregoing/attached transcript is a
true, correct, and complete transcription of said
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Date
Mary E. Young
Transcriptionist