NASA AEROSPACE SAFETY ADVISORY PANEL
National Aeronautics and Space Administration
Washington, DC 20546
VADM Joseph W. Dyer USN (Ret.), Chair

November 17, 2014

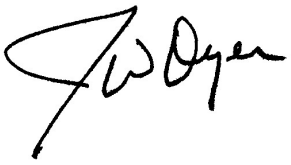
Mr. Charles F. Bolden, Jr.
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Bolden:

The Aerospace Safety Advisory Panel (ASAP) held its 2014 Fourth Quarterly Meeting at Marshall Space Flight Center, Huntsville, AL, on October 27-29, 2014. We greatly appreciate the participation and support that was received from the subject matter experts and support staff.

The Panel submits the enclosed Minutes resulting from the public meeting for your consideration.

Sincerely,



VADM Joseph W. Dyer, USN (Ret.)
Chair

Enclosure

AEROSPACE SAFETY ADVISORY PANEL
Public Meeting
October 29, 2014
Marshal Space Flight Center (MSFC)
Huntsville, Alabama

2014 Fourth Quarterly Meeting Report

Aerospace Safety Advisory Panel (ASAP) Attendees
VADM (Ret.) Joseph Dyer (Chair)
Dr. Patricia Sanders
The Hon. Claude Bolton
CAPT (Ret.) Robert Conway
Mr. John Frost
Dr. George Nield
Dr. James Bagian
Dr. Donald McErlean

ASAP Staff and Support Personnel Attendees
Ms. Harmony Myers, ASAP Executive Director
Ms. Marian Norris, ASAP Administrative Officer
Ms. Paula Burnett Frankel, Technical Writer/Editor

NASA Attendees:
Steve Cash, MSFC
Molly Porter, MSFC
Hal Bell, NASA Headquarters
Bill Hicks, MSFC
Steve Doering, MSFC

Telecon Attendees:
Mike Lapidus, SpaceX
James Dean, Florida Today
Paul Campbell, Lockheed Martin
Carlos Westhelle, NASA
Marla King, NASA Headquarters
Diane Rausch, NASA Headquarters

Opening Remarks
The ASAP Chair, VADM Joseph Dyer, called the meeting to order at 1:00 p.m. and welcomed attendees to the public meeting. He noted that the Panel had just concluded the 4th quarter fact-finding meeting, October 27-29, at Marshall Space Flight Center (MSFC *or* Marshall), Huntsville, Alabama. Before moving to the meeting topics, VADM Dyer commented about last night's incident at the Wallops launch site in Virginia:

> *Almost without exception, the ASAP members have significant flight test experience in industry and/or government. It is no surprise to us that these things happen, and we recognize that they are part of a system that is maturing and that is part of balancing risk and reward. NASA has considered this in limiting the commercial cargo manifest to non-critical packages. We note also: there were no reports of injuries, and it appears that launch processes and safety protocols protected the public; we are confident that the ISS logistics are in good shape, and we are confident in the supply chain; and we look forward to Orbital and FAA, with NASA support, carrying out the work to understand what went wrong, making changes as required, and expeditiously continuing the program.*

VADM Dyer noted that first on the agenda was Mr. Patrick Scheuermann, Marshall Center Director, who welcomed the Panel and shared a quick overview of activities that are being undertaken at the Center, which are certainly focused on space launch systems, but also include advanced manufacturing techniques and some very creditable work on infrastructure reduction. MSFC has an annual budget of about $2.2 billion and is a national treasure. Challenges at Marshall, not unlike the rest of NASA, include demographics and a workforce that is almost 50 percent retirement eligible in the near term. One of the things that Marshall is doing (and the ASAP hopes the rest of NASA emulates), is putting significant emphasis on hiring college graduate ("fresh-outs") to adjust the demographics and the robust hiring that was done almost 30 years ago and hasn't been done since. The Panel also had an opportunity to spend time with the NASA Administrator, Mr. Charles Bolden, the NASA Associate Administrator, Mr. Robert Lightfoot, and the Associate Administrator for the Human Exploration and Operations

Mission Directorate (HEOMD), Mr. Bill Gerstenmaier. After having the opportunity to spend time with these folks, the ASAP takes great confidence in NASA's direction and leadership.

The first topic shared by the Panel was on Infrastructure Management.

Infrastructure Management

CAPT Robert Conway reported that the ASAP had an excellent briefing from and discussion with Mr. Steve Doering, Director of the Office of Operations at Marshall. He provided an overview on what MSFC is doing for its building assets and evolving toward the future, with the primary function of providing infrastructure for the NASA missions. It is a very well-run effort and program. Their excellent plan being executed extremely well and objectives are being met, which include achieving cost savings that go back to the programs they support. Mr. Doering broke the objectives into three areas: facilities and infrastructure management, deferred maintenance, and energy sustainability and management. He is taking the project management approach to this entire effort, which is very successful. The statistics are overwhelmingly positive. The Marshall facilities support three main missions: the Space Launch System (SLS), the James Webb Space Telescope (JWST), and the International Space Station (ISS). In order to become institutionally cost-competitive, MSFC must "right-size" its infrastructure, which spans all the way from the 1940s through present day, with two big buildups (the 1940s for World War II and the Apollo era), bringing that infrastructure down from 5 sites—the Santa Susana Field Lab, ATK, Kennedy Space Center (KSC), Michoud Assembly Facility (MAF), and MSFC—and from 422 buildings to around 250 buildings. Mr. Doering said that his team is collaborating with the engineers and partners to ensure right-sizing the infrastructure to meet the needed capabilities at Marshall. He also keeps the Technical Capabilities Assessment Teams (TCAT) in mind to make sure all priorities are aligned. This is accomplished by eliminating external leases, demolition, "mothballing" (a state of inactivity), and refurbishment/replacement.

Mr. Doering discussed "deferred maintenance," which all the buildings have to some degree, and the cost associated with it. There is a constant flow of maintenance that needs to be done. Maintenance not performed goes into a backlog categorized as deferred maintenance. Deferred maintenance is eliminated by direct maintenance and repair, repair or replacement, demolition or transfer, or development of a public or private partnership. In FY14, MSFC is leading the agency in percent decrease of deferred maintenance and total cost reduction. Energy sustainment and management are additional tools that help reduce infrastructure costs. Three areas that are being examined are potable water, fleet management (government-owned transportation on the Center), and power consumption. With respect to energy, an Executive Order required 30 percent reduction; MSFC has already achieved 27.7 percent by the third quarter of this fiscal year. There has been some "low hanging fruit" where energy savings have been realized—installing electrical meters, negotiating demand billing, and replacing inefficient buildings with LEED (Leadership in Energy and Environmental Design) buildings. In all of these things, Mr. Doering is on the lookout for how to improve, e.g., for solar options and other renewable energy sources. The energy costs have been reduced from a projected $27 million (M) energy bill in 2009 to around $19.5M in FY14, even in an era of rising energy costs. This is a very well run and efficient program. There is an excellent plan with a deliberate process and strategy. They are meeting and exceeding federal benchmarks as well as Marshall objectives.

VADM Dyer noted that in the past, the ASAP has had some poor briefings on this subject; this is the first one that had true energy, focus, and direction. It was not lost on the Panel that Mr. Doering, with a program manager's background, focuses on cost, schedule, and performance. The ASAP complimented Mr. Doering on the excellent progress that has been made.

Mr. Claude Bolton added that in Mr. Doering's presentation, he showed the downward trend in energy usage as well as the increase in energy costs. It was good to identify that and ask the question: What else can we do to be energy efficient to bring the costs down? It will be interesting to see what NASA will do to continue in the right direction.

MSFC Technical Capabilities Assessment Teams Strategy

Dr. George Nield explained that the TCAT is a strategic planning initiative led by Mr. Lightfoot. It is examining all of the work being done at the NASA Centers and where the capabilities are to identify gaps and overlaps in an effort to become more efficient under limited budgets. MSFC is involved with four core product lines: space transportation and launch vehicle technology, propulsion systems technology, space systems technology, and scientific research. They have also identified 26 core capabilities and 96 fundamental capabilities. About 130 MSFC facilities and labs can be mapped to those capabilities; about 100 of those have already been identified for "deep dive" analysis. The TCAT process is a four-step process: data input, analysis, decision, and institutionalization. There are 21 different deep dives ongoing: 11 involve solutions, 10 involve capabilities. Decisions have already been reached in seven of the deep dives. Currently, there is work in process to name Agency capability managers in some of these areas to focus the effort. In terms of overall schedule, it is expected that this phase of activity will wrap up in the February 2015 timeframe. From then on, NASA and its Centers will be able to discuss its capabilities each year as part of the ongoing budget process. This was an interesting briefing by Mr. Jim Reuter; good work is being done, and the ASAP looks forward to the completion of the process.

VADM Dyer noted that he and Dr. McErlean have led similar undertakings. They are difficult and complex because one is trying to look across an enterprise to optimize resources. At the same time, NASA is pursuing some competition between Centers. The ability to integrate and compete is always a challenge. If NASA has an essentially flat-line budget, efficiencies will be essential if NASA is to do more exploration and science. The Agency is lucky to have Mr. Lightfoot's personal attention and energy in this undertaking.

Dr. Donald McErlean noted that it is important to point out the significance of the thrust into capability management at the Agency level. In a budget-constrained and hiring-constrained environment, if one can manage a critical capability across the Agency, one has the opportunity to apply resources where needed and avoid a situation where one Center has a need for a particular type of skill and another Center may have staff with that skill who are out of work. The ability to apply resources cross-site to accomplish the work that the Agency needs to get done is an incredible efficiency and cost-saving advantage and can advance the mission at a higher rate.

Dr. James Bagian reported on the next two topics, the Asteroid Redirect Mission (ARM) and the Institute of Medicine (IOM) report on health standards for long duration and exploration spaceflight.

Asteroid Redirect Mission

Dr. Michele Gates, ARM Program Director, and Mr. Steve Stich, the Crewed Mission Lead for this activity, provided an overview of the mission. They pointed out that this is part of the overall plan of going from shorter-term missions that are Earth Reliant to Proving Ground missions that are longer duration (up to a year) to Earth Independent missions. The target for the ARM would be in the mid-2020s. The three main segments for the mission are to identify the targets, then bring the asteroid into the cis-lunar environment, then bring the crew out to it. For the redirect aspect, they plan to use Solar Electric Propulsion (SEP). ARM offers a good testbed for this technology. There are two options for retrieving the asteroid: (A) a sample from an asteroid is "enveloped" and brought back to the cis-lunar environment, and (B) a small asteroid is captured with a device that moves it to the cis-lunar environment. They will make a decision in next couple of months on whether they will go forward with Option A or B. They will also need to develop a docking system that they will test on ISS. Mr. Stich talked with the ASAP on how they are innovatively making use of existing equipment for suits for extravehicular activity (EVA) and Orion. They are pursuing the idea of using the Advanced Crew Escape Spacesuit (ACES), which is the orange suit that was used on Shuttle from 1988 to the end of the program. By making small modifications to the ACES, it could be used as an EVA suit. In order to do that, they need to develop a new Portable Life Support System (PLSS) or "backpack." The crewed mission would be in the 25- to 28-day range for 2 people. The other advantage of the mission is to provide development opportunities for technologies such as solar electric arrays, SEP, and EVA capabilities that may be used for future endeavors such as Mars. The earliest target for Option A would be 2024; the earliest target for Option B would be 2025.

Institute of Medicine Report on Health Standards for Long Duration and Exploration Spaceflight

The briefing to the ASAP was presented by Dr. Richard Williams, NASA's Chief Health and Medical Officer, and one of his colleagues, Dr. David Liskowsky. The work performed by the IOM, commissioned by NASA, was to develop a framework by which they could deal with some of the questions that come up on long duration spaceflight and issues on crew health such as radiation exposure and what to do with risks that would be above what the current standards allow. Radiation is the one that comes to mind to begin with and is one that NASA currently is not sure how to deal with. The questions are: Can you mitigate the risk? Does this mean we don't go? How do we do that in a methodical, transparent way so that people understand what criteria are being used and how decisions are made? Up to this point, there had not been a very lucid methodology to evaluate risk and guide operational plans.

To summarize from the briefing, the major ethics principles in the development and implementation of health standards for decisions on long duration and exploration spaceflights are: avoid harm, beneficence, favorable balance of risk and benefit, respect for autonomy, fairness, and fidelity. Another ethics responsibility related to the standards is informed decision-making (known in medicine as informed consent), so that the crew members understand the risk they are taking. Dr. Williams and Dr. Liskowsky also talked about continuous learning strategy—how they make sure they learn from what they do. The report directed that there should be independent advice to look at this and give some credibility to it. Everything should be done in a transparent manner. The Panel thought that those were all proper recommendations and recognized that NASA has done many of these things already; however, rather than rely on people's good judgment, this approach codifies it and provides mechanisms and processes for handling exceptions. Exceptions should be done on a case-by-base basis, and there shouldn't be broad-ranging or permanent "waivers." In summary, it was a good, thorough methodology. They have not yet defined how to implement this, and they now need to work on that aspect.

Dr. Bagian agreed with VADM Dyer's observation that the activity provided a good framework and checklist for touching all the bases, but if one is looking for answers to technical or ethical questions, e.g., how much radiation can be suffered on a trip to Mars, one will have to look elsewhere. Dr. Bagian added that actual decisions will be based on what the facts are at that time. Answers will be situational.

Mr. Bolton commented that now they have a posed framework, but they shouldn't stop there. Over time, the ASAP should take another look at it and see how it evolves. The work is not completed yet.

Dr. McErlean noted that the evaluation of the risk, as ultimately presented to the individual who will take the risk, is an individual evaluation. In other words, it is possible that some astronauts may have higher or lower tolerances to a particular hazard. Each individual astronaut affected by the mission's selection would have an individualized risk folio upon which he or she could make an informed decision using data appropriate to the individual. The individual assessment aspect is an important piece.

Mr. John Frost commented that they have made huge progress; a year ago, NASA was embarking on a long-range master plan to explore into the solar system, possibly Mars, with the knowledge that as of today, there is no technology that can get radiation limits to the acceptable levels. This could result in spending billions and years and then saying "no, we can't go because of violation of standards." Now, NASA has a framework on how that decision could be made early enough to guide how this problem can be attacked. He cautioned that this doesn't mean they have made the decision; rather, they have laid out the framework for making a decision. They need to continue to watch this and make a decision early enough to guide where they are going.

International Space Station

Dr. Patricia Sanders noted that Mr. Mike Suffredini, ISS Program Manager, once again provided an exceptional and thorough status update of ISS activities. It is clear that it is a very active platform. As has been his practice, Mr. Suffredini first covered the flight plan or manifest. In concert with that he provided the status of supplies and consumables. To the credit of NASA management, they have a resupply approach that (1) keeps them ahead of the need curve and (2) a flight plan that spreads resupply across vehicle flights so that no single resupply flight is essential to sustaining the mission. One flight that has particular significance is ATV5—the last of the ATVs—which upon completion of its stay at the ISS will serve as a pathfinder for understanding the key factors of the shallow reentry regime that will be part of eventual ISS deorbit.

As usual, Mr. Suffredini gave the Panel a thorough review of recent EVAs, crew utilization, research conducted, and issues resolved or in work. The ASAP remains impressed with the straight-forward discussion of challenges that are being addressed as they arise in the normal course of operating in a very difficult space environment. It is truly a challenging environment that keeps them working on the edge, yet each issue faced and resolved brings greater understanding of what is needed to exist and operate in space.

The ISS crews are extraordinarily busy. Besides performing maintenance, medical activities, environmental monitoring, and other operations, they approach 40 hours per week on payload investigations. During the last 2 increments, they have been involved in 428 investigations including 66 of which were internationally led. One of the most intriguing investigations that was discussed was the recent rodent research. An item of particular ASAP interest has been the plan for ISS end of life (EOL), both nominal case and contingency deorbit. While the planning is still not complete, the ASAL appreciates the progress that has been made over the past two years, including securing necessary agreements with the ISS partners.

Finally, it was noted that in discussing the ISS top program risks, the top four or five are directly related to budget or budget uncertainty, which is largely outside the control of the Program Manager, but with major potential consequences for the execution of his mission. Mr. Suffredini continually faces a challenge in sustaining the ISS within the context of these risks, but appears to be dealing with them very well.

The next two topics, Exploration Systems Development (ESD) and the Agency loss of crew (LOC)/loss of mission (LOM) decision process, were addressed by Mr. Frost.

Exploration Systems Development Update and ESD Risk Acceptance

The ESD update was provided by Mr. Bill Hill, the Deputy Associate Administrator for ESD, HEOMD. ESD is NASA's flagship program: it includes SLS, Orion, and the Ground System Development and Operations (GSDO)—three major programs that must work together. In the past, the Panel has talked about subsystem tests and component progress, and it is good to see pieces being bolted together. The first flight test, Exploration Flight Test (EFT)-1, will occur on December 4, 2014. Orion will fly on a Delta IV heavy to obtain early test data on many of the subsystems, particularly the heat shield. It will be a full test of the heat shield and the entry system. This is state-of-the-art and needs to be scoped out early. Next, there is Exploration Mission (EM)-1 with a planned launch window of FY18. It will be uncrewed, but will be carrying almost every system needed for a safe, crewed flight. The EM-1 flight will tell NASA a great deal about the system. EM-2 is about seven years away. The current thinking is that it will be the first crewed flight. That aspect led to extensive discussions on safety-critical subsystems, some of which would not have been flight tested prior to EM-2. However, they will be tested extensively on the ground. These include the pressure control system, the air reutilization system, and fire detection system, among others. This will also be the first flight with a new upper stage. This approach is different than one would like to do it in an ideal world, but the Program has addressed the risk that it creates. The actions include things such as extensive ground testing of the subsystems as well as ISS in-space testing. It was mentioned that they have ensured that crew will have the capability to survive in the suits alone if they had to. It appears that they are mitigating and managing the risks. However, Mr. Frost urged them to think very carefully about those risks as they scope out what the EM-2 mission will be and to continue to minimize risks.

As part of this review, the ASAP took a "deep dive" into investigation of an anomaly that the SLS Program has had. The Panel's interest was more about their process for investigating anomalies than the particular anomaly itself. This anomaly involved a void that occurred in one of the solid rocket motors—Qual Motor 1. By non-destructive testing, a 5.7 inch void was detected. In solid rocket motors, voids can lead to over-pressurization and explosion. The team is paying a lot of attention to this and has developed several techniques to make these voids much less likely. Those will be tested. The requirement is for zero voids, but this is hard to attain in the real world. Mr. Frost encouraged them to investigate using subscale or full scale testing to try to establish what the actual void limits are. It would be a good addition to their suite of corrective actions. He noted that they are considering that.

Agency LOC/LOM Decision Process

Mr. George Gafka, the newly appointed Chief Safety and Mission Assurance (SMA) Officer in ESD, took the ASAP into a very good philosophical discussion of the NASA risk process, particularly how the Probabilistic Risk Assessment (PRA) deals with the question of "unknown unknowns"—things that one didn't recognize as hazards that pop up and cause risk to be different than one thought. He explained the NASA approach. When they do a PRA or an analysis of the theoretical level of probability of loss of crew, it is based on the design capability of the system—how good the system will be when it matures. That is what they are assessing. They recognized that early in its life, it might not be as good as the mature model would be. What that means in simple terms is there may be more risk in the early flights than what the PRA would indicate. The importance there is not to be misled and think that the PRA gives a true assessment of what the safety levels will be. It is a tool that is best used to analyze options. It gives an order of magnitude of safety level. However, especially in the early flights, one should not expect the level of safety that a PRA will indicate that will eventually be achieved. This presentation was a good clarification of some issues that the Panel had discussed in the past.

VADM Dyer noted that the Panel's interest in LOC/LOM statistics is centered in two areas: on the one hand, a LOC objective and threshold can and should influence design; it is one of the answers to "how safe is safe enough?" On the other hand, the Panel thinks that LOC (or something akin to it) is necessary to communicate to the White House, the Hill, and the public that space is risky business and should always be considered as such.

Dr. McErlean reinforced what VADM Dyer said. He noted that Orion and SLS are moving ahead very well, but there are risks that are being faced by the technical teams all the time. While the very best people are analyzing the potential for failure and the results of potential failure, there is no 100 percent absolute mechanism to preclude all chance of failure; that doesn't exist in the real world. Orion has the world's largest heat shield, but it has not yet returned from space. Although the engineers have very high confidence that it will work, and the ASAP has confidence in them, it is still the first test. The issue with the solid rocket motors that Mr. Frost discussed is a typical example of what sometimes happens when things are improved. The new material that they have put into the rocket motor is superior in many ways to the material that was used on Shuttle, but it seems to have developed this one peculiar characteristic that they are working on solving—the issue of propellant void. This is a difficult business, filled with complex and difficult technical systems. The best of our ability to test them, to predict what their behavior will be, and to analyze the potential results does not make the risk go to zero. The word "safe" in the context of the way it is used everyday in our homes simply does not apply to space travel. "We make it as safe as we possibly can, consistent with the risks that we have to take in order to go."

Dr. Bagian emphasized that there is never zero risk. Last night was a good example; these things will occur. As currently planned, there will be a lot of systems flying for the first time. There will be thorough ground tests, but one never knows how everything will play together until one actually gets there. That has been seen numerous times in the past. However, the communication of that risk is very important. The risk to the program is loss of confidence if they have a problem and the public does not realize that those risks were well understood by NASA. The people running the program thought that the countervailing benefits (the value) balanced the risk of a bad outcome. If that communication is only done after the fact, it often can be heard as self-serving rationalization. That needs to be very candidly understood. As VADM Dyer said about the incident last night, "these things happen," and they are going to happen periodically. As long as they happen for reasons where a prudent risk was taken, everyone has to understand that and not go into a three-year hiatus or excessive delays if a bad outcome is experienced—one that was accepted to begin with. It is important to do that first. Sometimes NASA has not done that as candidly or as clearly as they might.

Mr. Bolton said that he was encouraged by the methodology shown in addressing risk and the unknown unknowns. As mentioned in the briefing, they seem to be on the leading edge of how to better understand the risk, but it cannot be completely eliminated.

Commercial Crew Program

Dr. Nield reported on the briefing and discussions with Mr. Wayne Ordway, the Commercial Crew Program (CCP) Associate Program Manager. They are nearing the end of the phase known as Commercial Crew Integrated

Capability (CCiCap). Three companies have been working under Space Act Agreements (SAAs). As part of that effort, Boeing has now completed all of its milestones. Both SpaceX and Sierra Nevada (SNC) have a few remaining milestones that they plan to finish up in the months ahead. The big news recently is on Commercial Crew Transportation Capability (CCtCap), under which NASA has selected Boeing and SpaceX as contractors to provide commercial crew transportation capability. As previously announced, SNC has filed a protest with the General Accounting Office (GAO) on that decision. This will involve a 100-day process that will culminate in the first week of January 2015. In the meantime, the Court of Federal Claims has agreed with NASA's ability to continue performing the contracts during the protest period. Both Boeing and SpaceX have completed their kick-off meetings and are working on the certification baseline review milestones. Other accomplishments from the program office are: NASA has completed a program organization realignment that should provide a more efficient structure in managing the certification process; they have come to an agreement with the Launch Services Program (LSP) on roles and responsibilities to support the CCP; there have been ongoing discussions within the government interagency community, including with the Federal Communications Commission (FCC) on spectrum usage; they continue to see good progress with the Federal Aviation Administration (FAA) and U.S. Air Force (USAF) 45th Space Wing on issues associated with launch and entry. NASA has also established a Standing Review Board that will provide additional advice to the program as it goes forward. The chairman has been selected and members have been identified and vetted. They will start work soon. Going forward, NASA will provide continuing support for the remaining CCiCap providers and their milestones. The Panel expects to see NASA continue to assess the resource needs to accomplish certification tasks with two providers. They will be trying to formalize and finalize the schedule leading up to Key Decision Point (KDP) 1, an important programmatic milestone.

General ASAP comments:

Dr. McErlean noted that when the Panel talked about ISS, it missed an opportunity to say "good job" on EOL planning. About a year and a half ago, the ASAP initiated conversations with the ISS Program about EOL planning and deorbit. They appear to have taken on that job seriously. They have recently signed agreements with the international partners on how parts of the process are going to be handled, and they are moving down the path.

By way of coming attractions, VADM Dyer announced that the ASAP will be undertaking activities in preparation for its 2014 Annual Report that will be published in mid-January 2015. One of the things much on the Panel members' minds is NASA's sustainment of direction or constancy of purpose associated with ongoing programs as they transition the change in presidential administrations. Looking at the history of U.S. space programs over the last several years, one will see that too often a new administration brings new direction. If that continues, it will be a long way to Mars. The Panel will be working on some graphics and a better understanding of these factors.

There were no public comments, and VADM Dyer adjourned the meeting at 1:55 p.m.