HMI INTEGRATION
Andrea Mattern, SDO Mechanical Engineer

HMI looks at the outside of the Sun to try and determine what is happening on the inside.

The SDO team is in the clean room preparing to lift the HMI Optics Package or HOP. We lift the instrument slowly and carefully to prevent any damage. The instrument is being rotated to get it into the correct orientation to integrate to the instrument module. It takes about 20 minutes from the time the HOP is lifted from the shipping plate to the time it is rested on the instrument module. Once it is verified that the instrument is secure, the spacecraft is rotated. The purpose of rotation is to gain better access to different parts of the spacecraft. In this particular case we are rotating to gain access to HMI to remove the lift fixture.

SDO OFFICIALLY AN OBSERVATORY
Narration: Brent Robertson, SDO Observatory Manager

A major milestone was reached when Goddard engineers recently attached the instrument module to the spacecraft bus transforming it officially into an observatory. With its three instruments (AIA, EVE, and HMI), SDO will deliver startling images of the Sun that are ten times better than HD!

We had a big day planned for Solar Dynamics Observatory. We wanted to integrate our instrument module, which contains all of the instruments to a spacecraft bus, which contains all of the electronics we use to point the satellite and control the satellite. This was a big operation for us. It's a critical lift and a lot of preparation went into this operation. We have folks working on the spacecraft bus preparing it. We had folks working on the instrument module in preparation for the lift, and a lot of folks contributed to this overall effort. Here's a great shot of one of our telescopes, instrument telescopes. You see there are four large telescopes and adjacent to those telescopes are four smaller guide telescopes that we use to point the satellite to the sun. The instrument module was lifted off the Aronson table and slowly moved over to the spacecraft bus in preparation for the meeting. All eyes were on this operation and we had folks in place to make sure that we had no interference problems when we finally did the mating. It took a lot of people in the cleanroom to make this operation happen and, you know, we were all talking with each other making sure that everything went well. Anybody can stop this operation if they saw a problem, but things went well that day. You know, we've been working on this mission for about five years, so to get to this point where we have a finally integrated observatory was a great day for us.

INTEGRATING PROP AND RING
Narration: Gary Davis, Sub Systems Lead

Mating the SDO propulsion tank and the launch vehicle payload attach fitting is done to enable Goddard engineers to perform a dry vibration test of the. Slow and care are key.

This is the Solar Dynamics Observatory propulsion module in the black bag there, being lowered down onto the launch vehicle payload attach fitting, which is the gold colored ring at the bottom. You can see on the edges we have red thruster covers which are protective covers to make sure that the thrusters on the corers don't get damaged during the lift. We lift down the propulsion module onto the path ring very carefully, and mate the two together. This is the launch vehicle interface mate for the flight, and the reason we are mating them is so we can perform a dry vibration test of the propulsion module. It's too hazardous to load the propulsion module with our rocket propellants for this test so we put a silver ring on top of the module to simulate the weight of the propellants. And then once the two are mated together, we perform the vibration test.

<u>PROPULSION AND BUS INTEGRATION</u>
Narration: Brent Robertson, SDO Observatory Manager (6-9639)

After launch, SDO's propulsion system will boost the spacecraft into its geosynchronous orbit. Thrusters using the same fuel and oxidizer mix will keep SDO in the correct orbit during the mission. The Bus carries the electronics and battery for the spacecraft.

OK, here's our SDO propulsion module and over here is our spacecraft bus and we're about to mate the spacecraft bus to the propulsion module. This was a big event for us. Here you see that the lifting sling is attached to the spacecraft bus, and we're slowly lifting that bus to place it above the propulsion module. The spacecraft bus contains all the electronics that we've built up over the past year to control the satellite and eventually send the data down to the ground. It's a very complicated piece of structure and we want to make sure during this operation that we don't have any issues with interference of blankets, harness, or mechanical structure. We've prepared well in advance for this operation. Everything's planned out very meticulously and written down. We want to make sure we don't have any issues. You can see the complicated nature of the spacecraft bus electronics. It's slowly lowered down onto the propulsion module and we have people watching this operation and helping out with the lowering of the bus onto the propulsion module. Every person has a role to play during this operation and any person could stop the operation if we were to encounter a problem. You can see the spacecraft bus is slowly lowered down, while all our engineers and technicians watch for any interference issues that we might have. All of this operation is recorded. You can see our photographer. We're getting towards being able to mate it. This is a big event for us. We've been working for the past year on the spacecraft bus building up the electronics and propulsion module for the past year as well, building that up. And here it is mated together.

<u>EVE INSTRUMENT ARRIVAL</u>
Narration: Narration: Andrea Mattern, SDO Mechanical Engineer
Danielle Vigneau-Grace, SDO Instrument Lead

The Extreme ultraviolet Variability Experiment (EVE) measures the solar extreme ultraviolet irradiance or "density of radiation" with unprecedented spectral resolution, temporal cadence, accuracy, and precision to advance the understanding of the solar EUV irradiance variations based on the activity of the solar magnetic features.

The SDO instrument arrives using Fed Ex custom critical, white glove service. Shipping this way allows us to control the temperature and the humidity throughout the shipment process. Here you see some of the ground support equipment for the EVE instrument being unloaded from the truck. And here you have the spacecraft simulator, and the blue box contains the EVE instrument itself. This was the first instrument to arrive for SDO. The SDO team is moving the shipping container down the hallway to the clean room tent where it will have a post-shipment checkout. It is important to do functional testing to make sure nothing happened during the shipment. The EVE instrument is being lifted with the crane and is going to be loaded onto a rolling dolly and it will remain on the dolly in order to be transported from activity to activity.

HMI ARRIVAL

Narration: Andrea Mattern, SDO Mechanical Engineer
Danielle Vigneau-Grace, SDO Instrument Lead

The primary goal of the Helioseismic and Magnetic Imager (HMI) investigation is to study the origin of solar variability and to characterize and understand the Sun's interior and the various components of magnetic activity

This is HMI, also known as the Helioseismic and Magnetic Imager being wheeled into the cleanroom. Here we see it in its shipping container. Once it's inside the cleanroom a purge line will be attached to keep the instrument from getting contaminants, and also a ground strap will be attached because the instrument is electrically sensitive. That's a view of the HMI harness on the harness mock up and, as you look over there, you see the granite table and the instrument's being lowered down in a very level way in order to prevent binding of the four pins. There are six mounting feet. As you pan back you'll notice the spacecraft on your left and someone on the rolling staircase prepping the area for the electronics box. That's a view of HMI from the top. You can see the aperture on the front.

HIGH GAIN ANTENNA/SOLAR ARRAY DEPLOY

Narration: Jason Hair, Deployable Systems Lead

To send the downlink signal while flying in orbit, SDO's High Gain Antennas (HGA) needs to be pointed towards Earth. The solar arrays are there to convert the energy from the sun into DC power for the satellite and its instruments.

The Solar Dynamics Observatory has two high gain antenna deployment systems. We are testing this system today to make sure that it will deploy properly once it reaches space. We use a counter-balance system, which you can see in the lower right, to off-load the sense of gravity so we can properly simulate the deployment here on the ground. We monitor this deployment using electronics and computer systems to make sure the deployment performs as we expected. In this case we had a very successful deployment and we are now going with the confidence it will work properly when we reach orbit. As you can on the antenna system we have blanketing that protects it from the sun, and also a composite antenna that helps maintain minimum weight and optimum performance. We also test the solar deployment system in a similar manner using counter balances. In this case, we're using a non-flight panel to help us with this test. The large bang you hear, unfortunately, won't be heard in space, but makes for an exciting test on the ground. Now this is a test panel, as I mentioned, but we will be receiving the flight panel shortly and performing the test again with that flight panel.

BATTERY INTEGRATION ON THE BUS

Narration: Denney Keys, Power Systems Lead

This battery will provide all the energy SDO needs while in orbit. It is charged by using the sun's energy collected by the solar array panels.

Here we are in the process of un-wrapping the spacecraft battery. We have to keep it clean since it is in with the spacecraft. As you can see, the battery itself is primarily used to provide energy to the spacecraft during eclipses, which occur twice a year. At this point in time, we are installing a fixture on top of the battery so that we can lift the battery up in order to align it and put it on the spacecraft panel where it will reside. The reason we have to use a fixture and a crane in this particular case is because the weight of battery itself is on the order of 90-95 pounds. We have to very careful as we move the battery in towards the panel in order to avoid any damage to electronics that are very close by. Once we have the battery in close to the panel, it's aligned for all the mounting bolt holes, and bolts are installed and torqued down in order to hold the battery securely in place on the panel. Once all the bolts are installed, the battery is there on the panel and ready to provide all the energy SDO needs. And there you have it.

PROPULSION TANK INTEGRATION

Narrator: Gary Davis, Propulsion Lead

SDO's Propulsion Tank, with pyro-technic valves, will send the fuel to various thrusters on the observatory's main engine for launch.

What we're going to see here is the lift of the SDO Propulsion Module Fuel Tank. This is the clean room in the background where we do all the integration of the subsystem to keep the inside of the propulsion system clean and this is the lifting sling that we use to lift the tank. The tank is lifted from a flange on its equator and we have three lifting points covered in white foam to protect the tank surface when we lift it. The tank is made out of titanium and the fuel tank is covered on the top half of the tank with aluminum tape to help spread out heat from its heaters, and the bottom half is covered in kapton tape. So we attach it and then we lift the tank, and we are lifting it into this piece of structure that is the cylinder. The tank is lowered slowly into the cylinder and there's not much clearance up where the equator of the tank is. So we lower it very slowly and carefully those last few inches to make sure that nothing is hitting. Then once the tank is mated down to the flange of the cylinder we attach it with bolts and nuts around the outside of the flange. This is the propellant control module that routes the distribution of the propellant from those tanks to the various thrusters on the main engine on the propulsion sub-system. It contains pyro-technic valves, pressure transducers and latch valves. Finally, this is the propulsion module, including the cylinder and the fuel tank on the very top.