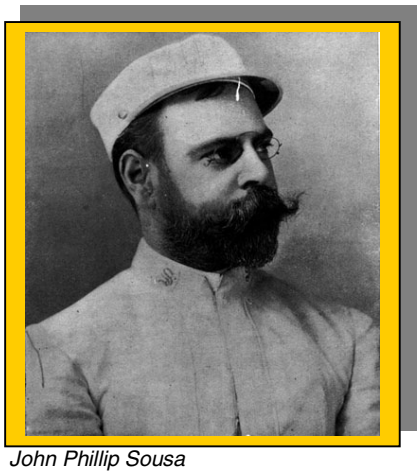
Dynamic Design: The Cleanroom

A Scientific Symphony and Tool Time

STUDENT TEXT

In the activity "Working Together" you complete a task by working in teams. Often the best products are a result of many people working on the same task in harmony. Think of the skyscrapers or sports stadiums that require people from all walks of life to work together to make it happen. No one person who works on these large structures could construct it alone.



John Phillip Sousa

In the Genesis cleanroom, it takes three people to install the wafers on the array frame. If any one of these people makes a mistake, then that part of the assembly may have to be redone. Watch the video clip that shows the wafer assembly. As you watch the scientists in the assembly process, it might remind you of a trio of musicians playing different parts of a song together.

To illustrate this listen to the United States of America's National March "Stars and Stripes Forever" by John Phillip Sousa. Go to http://www.dws.org/sousa/ra/dws-ssf1.ram to listen to the march using Real Player®.

Stars and Stripes Forever

In most band music there are many instruments that play different parts so you hear melodies, harmonies, and rhythms. As you listened to this familiar march you may have noticed that there are three themes highlighted throughout the song. Sousa wanted the three themes to represent different regions in the United States. If you listen again to the Dallas Wind Symphony's performance of "Stars," as Sousa called it, you can hear the three themes. The first theme is the familiar melody, which starts about one minute into the march. This main theme represents the northern part of the United States, which is full of contrasts and diversity. The second theme can be heard at the two-minute mark. This is the swinging sound of the piccolo, which represents the south. Finally the rugged west is symbolized by the counter melody of the trombones, which is heard at the three-minute mark. When you listen carefully to this last part of the march, you can hear all three themes being played together. When played in synch the sounds can cause people to respond by rising to their feet and marching. Sousa once said that *his* music could make a man with a wooden leg get up and march.

Returning to the cleanroom and the assembly process, Contamination Control Lead Scientist Eileen Stansbery describes the orchestration of putting the array together in this way. " To install this [array frame] vertically it takes about three people. One person to hold the wafer in place, one person to hold the retaining rings in place and one person to mount the screws and screw the screws in." Watch this video showing this process in detail taken during the filming of "*Cleanroom Technology: NASA Genesis Mission."* As you watch the scientists assembling the wafers on the array frame, notice the oral and non-oral communication that takes place. Watch the video again and notice the order in which different people complete various tasks.

Vertical Installation

First, you noticed in the video that the array frame is in the vertical position during assembly. This is to minimize debris from falling on the pristine wafers. When a screw is screwed into the frame, tiny metal particles are released from the friction between the surface of the screw and the hole. By having the array frame vertical, the contamination from the scientists and the debris from the screws will fall to the floor because of the laminar (vertical) airflow in the cleanroom. As often happens in science, after planning and practicing for vertical installation, at just about the last moment the Genesis payload team had to change the plans and install the wafers horizontally. Although they had practiced vertical installation,

the team used collector wafers made for the engineering model, for the "dress rehearsal" Vertical installation went fine. However, just two weeks before they were to start to install the real flight collector wafers, the payload team found that a few of the wafers were more fragile than expected. Specifically, the wafers coated with aluminum and with gold had such thin layers of coating that the wafer tweezers would immediately scrape off the coating as soon as they tried to pick up the wafers. So, at the last minute the Genesis payload team had to revise all of their plans. Horizontal installation was simpler in some respects, but still involved the group coordination and teamwork mentioned above. Horizontal installation also required cleanroom discipline in order to minimize leaning or reaching over the wafers during installation.

Horizontal Installation

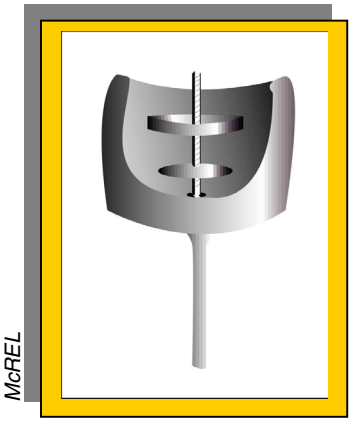
The array frame is laid flat on the cleanroom table; the gap shield is placed on top of it. All the bottom retainers are put into place, then all the wafers are installed (placed on the gap shield and bottom retainers), then the top retainers and fasteners are screwed into place. Wafers are installed using wafer tweezers, except for the gold and aluminum coated wafers. These were shipped lying horizontally, face down in containers. To pick them up, the Genesis payload team used a vacuum wand, which used suction on the back, uncoated part of the wafer. Once the wafer was lifted up out of the container, they turned it over and slid it onto the new wafer installation tool--a stainless steel spatula purchased at a cookware store. The only way to install the coated wafers without damaging them was to use a spatula and to slide them into place.

Here is what team member Kimberly Cyr had to say about this change in plans. “Our group had to be flexible and adaptable, as mission requirements changed at the last minute (common in the space mission world). We had to be creative to brainstorm a solution, and found a very simple, elegant solution which worked great, using ordinary materials you wouldn't usually associate with space flight.”

Tool Time

Oftentimes in science, special technologies are invented to fit a very specific task. In assembling the spacecraft in the Genesis cleanroom, some very cool tools were made. The parts of the array frame and the tools for assembly are described here.

The array isogrid frame is a grid of triangles. This is covered by a gap shield made of aluminum that prevents solar wind particles from falling between the gaps of the wafers and embedding into the array frame that is underneath it. The wafers are installed on top of this gap shield and are the boxes that collect the solar wind that will be returned to Earth in order to study the elemental abundances of the solar wind.



McREL

There are three tools that are used for installation. Normal tweezers or forceps are used to pick up all parts and to hold the retainers in place. Special wafer tweezers with a flat end are used to hold the wafer in place tightly while having minimal contact with the wafer. A special tool designed to line up the screw, flat washer and spring washer and top retainer in that order is used for installing the wafer. This special tool has some springs to hold all of these parts in place, so that nothing will fall out during assembly.

Johnson Space Center

Working together in harmony in the Genesis cleanroom to assemble the collector array is just one example of how people with different areas of expertise cooperate to complete an important objective. The overall Genesis mission has six partner organizations, each with people that have an important part in the mission. Partners include the National Aeronautics and Space Administration, Jet Propulsion Laboratory, California Institute of Technology, NASA Johnson Space Center, Los Alamos National Laboratory, Lockheed Martin Astronautics and Mid-continent Research for Education and Learning. The people in these partner organizations must work together in harmony for the mission to be a success. See a brief explanation of the different partner

organizations. Some of the people that make this mission a success are listed on the People section of the Genesis Web site.

According to A Science Educator's Answer to the Middle Level Curricular Question: "What About Us?," "Today's scientific research is not a lone pursuit, but is done by teams, generally of from six to eight people." Clearly, working together is an important aspect of accomplishing an objective whether the objective is assembling an array, launching a rocket or developing a NASA mission or performing band music. As you know in completing activities in science class, how well your group works together will determine how well the product turns out and how much you learn in the process. A group that has difficulty working together often has members that are frustrated and upset while a group that works well together can accomplish great things.