



## Spaceflight Meteorology Group STS-116 Post Mission Summary

### International Space Station Assembly Mission 12A.1

#### Mission Overview:

The Shuttle [Discovery](#) launched from [Kennedy Space Center](#) (KSC) Launch [Pad 39B](#) on the evening of December 9, 2006 at 8:47 PM EST (0147Z 12/10/06) and landed at the [Shuttle Landing Facility](#) (SLF) at KSC on December 22, 2006 at 5:32 PM EST (2232Z).

Weather played a critical role in both the timing of the mission's launch and the location of its landing. On the scheduled launch day, December 7, in the wake of a cold front, cloud ceilings at KSC were barely above weather flight rule limits. Conditions at the [Transoceanic Abort Landing](#) (TAL) sites were even less favorable. An approaching cold front caused low clouds at two of the TAL sites and showers at the third. The third site became "Go" well into the launch count, the minimum number of TAL sites required for a launch, but the launch was scrubbed. After a 48-hour delay, the shuttle Discovery launched into the nighttime sky, the first night launch in over four years. The astronaut crew of [STS-116](#) delivered two tons of supplies and installed a truss assembly on the [International Space Station](#). They also completed four space walks while docked to the station. While on orbit, the mission was extended one day, leaving only one day to land. Typically there are two or three days. This caused NASA to activate all three of its landing facilities; KSC, in Florida, the primary site; Edwards Air Force Base (EDW), in southern California, the secondary site; and, White Sands, New Mexico, a back-up site. Initially, going into the landing count, the weather at KSC and EDW appeared troublesome with a chance of showers at KSC and crosswinds at EDW. There were no serious weather concerns at White Sands. The first attempt to KSC was waved off due to showers. On the next orbit, the attempt to land at EDW was waved off due to crosswinds exceeding flight rule limits. With only minutes to spare, SMG advised the NASA Flight Director that conditions would be favorable at KSC and Discovery landed safely at KSC at sunset on December 22.

#### Launch Scrub - December 7:

A launch was attempted on evening of December 7th. Early that day a cold front moved south across Florida. Behind the front, stratocumulus clouds developed over central Florida. Cloud ceilings were barely above weather flight rule minimums as the launch time approached. In Europe, a cold front was also the main weather feature and it was affecting all three TAL sites, two with cloud ceilings below weather flight rule limits, the third with showers. Showers moved away from the third TAL site yielding "Go" conditions. However, even with "Go" weather conditions forecast for KSC and one of the three TAL sites, the minimum required, the launch was scrubbed due to a USAF range safety violation. This range safety scrub was the first time in shuttle history that a range safety violation caused a scrub with no other contributing weather violations. With "No-Go" weather conditions forecast for the following day, NASA declared a 48-hour scrub. The launch was rescheduled for December 9. Conditions on December 8th verified as "No-Go" with cloud ceilings below flight rule limits.

### Launch - December 9:

On December 9th, high pressure continued to build over Florida. An onshore low level flow again brought the threat of low cloud ceilings to KSC. As launch time approached, concerns for low cloud ceilings were removed from the forecast as a result of favorable weather reconnaissance reports. In the wake of the cold front that moved across Europe on December 8th, there were no weather concerns at the TAL sites. Discovery launched at 8:47 PM EST.

### Landing - December 22:

For a typical shuttle mission, three days are set aside at the end of a mission for landing. KSC is targeted on the first scheduled End of Mission (EOM) day. If the weather is unacceptable at KSC on that day, depending on the weather scenario, both KSC and Edwards Air Force Base in California are targeted on the second day. Only in rare instances are landings not made on the second day. This only occurs if weather conditions at both sites are unacceptable on the second landing day and pristine weather conditions are expected the next day at both sites. If no landing has occurred on either of the first or second day, landing must take place on the third day and at the site with the "best" weather. In another first, *the shuttle program gave up two of its three weather landing days for STS-116*; one day to extend the mission prior to launch to accomplish station re-supply and the other day during the mission to perform an unscheduled space walk to fold up a balky solar array. This allowed for *only one day to land* and the weather would present several challenges. NASA activated all three of its landing sites; KSC in Florida, the primary landing site; Edwards Air Force Base in California, the backup landing site; and White Sands Space Harbor in New Mexico. It should be noted that the space program utilized White Sands for a shuttle landing only once - early in the shuttle program, in 1982.

At the upper levels on EOM day, a deep trough covered the central U.S. A 100 knot jet extended from the central Gulf of Mexico to the Mid-Atlantic States. Large-scale lifting in the form of low, middle, and high clouds was occurring from the eastern Gulf into the southeastern U.S. At the surface, a strong high pressure system was nearly stationary over the Atlantic. A cold front was approaching the panhandle of Florida from the west with scattered showers and low clouds along and ahead of the front. There were also isolated thunderstorms along the front over the central Gulf. Scattered to broken mid and high clouds covered Florida due to the large-scale lifting. Over the western U.S., another 100 knot jet extended from the eastern Pacific southeastward over southern California. Weak ridging was occurring over New Mexico and western Texas ahead of the jet.

Low clouds were forecast to develop inland over Florida during the day due to daytime heating and instability. Showers were forecast to develop around midday, mainly along the west coast of Florida. Gusty southeast winds were forecast all day at KSC. The strong southeast low level flow was expected to bring scattered low clouds to KSC. There was also a risk of low cloud ceiling and showers. Out west, a cold front pushed through southern California and was moving towards New Mexico. No weather violations were expected at White Sands. At Edwards, north winds in excess of 50 knots at mid levels, 7,000 to 10,000 feet, were expected to cause winds across the runway to exceed crosswind limits.

KSC was targeted for the first available opportunity. However, scattered showers developed inland along the coast south of the Cape early in the afternoon. The showers were moving north-northwest towards KSC. Additionally, showers had developed from west of Lake Okeechobee northward to west-central Florida. These showers were moving northeast. SMG

updated the forecast to reflect an increased risk of rain showers. NASA waved off the first landing opportunity.

The winds at EDW, as expected, became northwesterly and gusty by early afternoon. The winds remained northwesterly into the mid afternoon but decreased slightly in speed with the crosswinds remaining just above the flight rule limits. When the first opportunity to KSC was waved off, the Flight Director, accepting the crosswind conditions, targeted EDW; keeping the second KSC opportunity available. As the EDW first opportunity landing decision time approached there was a change in the wind direction and an increase in speed. This resulted in crosswinds exceeding the weather flight rule limits by a larger amount than expected. The Flight Director waved off EDW and re-targeted KSC for its second opportunity.

Over Florida, the showers located far southwest of KSC had intensified as they moved towards KSC. Light showers between KSC and the heavier showers to the southwest had dissipated. SMG used the NWS Melbourne, FL WSR-88D radar imagery and AWIPS tracking tools to predict that the approaching showers would be on or just into the southwest portion of the 30 nm stand-off circle for the second opportunity. The forecast for KSC was amended, removing the showers and chance of low cloud ceilings from the forecast. The updated forecast was briefed to the Flight Director with the caveat that as long as there was no change in the speed of the strong showers or additional development, the showers would be on the edge of the 30 nm circle at landing time. The Flight Director gave a "Go" for the deorbit burn. At landing time there was a light shower with tops to around 7,000 feet in the western part of the circle, its leading edge 20 nm west-southwest of the SLF. Also, a strong shower with tops to 20,000 feet was encroaching into the southwestern arc of the circle, its leading edge 25 nm southwest of the SLF. Neither shower had an impact on the approach to a safe landing.

Although no weather violations were forecast for White Sands, it was not without concern. Mid and high clouds were pushing across New Mexico ahead of the approaching upper-level jet. As early as mid-morning, ground-based observers began reporting virga. However, radar echoes remained below the 18dBZ precipitation definition threshold level through the landing count and the weather aircraft verified that there was no visible moisture coming from the clouds.

For STS-116, Karl Silverman was the Mission Lead Forecaster, Tim Oram the Assistant Lead/TAL Forecaster, and Brian Hoeth was the Mission Lead TDU, Techniques Development Unit Meteorologist. On landing day, Karl Silverman, as Mission Lead, oversaw SMG operations and handled the forecasts and briefings for KSC. Tim Oram and Tim Garner handled the forecasts and briefings for EDW. Richard Lafosse handled the forecasts and briefings for White Sands. Brian Hoeth handled the upper-wind forecasts and briefings for the three landing sites.

Submitted by:

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