ABSTRACT
We assess the science impact of using a new coating for the reflective elements of WFC3. The new coating, LLNL EUVHRS, increases the throughput of the instrument at optical wavelengths at the expense of the UV, compared with the currently planned MgF$_2$ coated aluminum. Two possibilities have been identified, namely to use the new coating only on the pick-off mirror of WFC3 (single surface) or to use it on all its reflective elements (3 surfaces). The single reflection improves the throughput by approximately 7% at the optical wavelength (about 550 nm). However, it is 20% less efficient in the UV (at about 250 nm), than the current coating. The 3 surfaces reflection is 23% more efficient in the optical and about 70% less efficient in the UV. We calculate that adopting the new coating will allow WFC3 to carry out the DRM science programs with less total telescope time than required with the current coating.

Introduction
We have considered the impact on the science performance of replacing the currently planned coating of the reflective elements of WFC3. The new coating, the LLNL EUVHRS, offers improved performances at optical wavelengths (and, marginally, also at near-IR wavelengths) over the traditional MgF$_2$ coated aluminum at the expense of the UV performance. Two options have been considered: (1) the new coating is only used on the pick-off mirror of WFC3 (single surface reflection), (2) it is used in all the reflective elements of the instrument (3 surfaces reflection). In this TIR we assess the scientific impact of the adoption of the new coating in both the 1 surface and 3 surfaces reflection options.
by using the exposure time requirements of the Design Reference Mission (DRM) programs.

**Coating Data**

The efficiency data for a coating applied to a single surface are shown in Figure 1. The efficiency data for a coating applied to 3 surfaces are shown in Figure 2. The proposed coating is referred to as LLNL. In the calculations we used the reflectivity that corresponds to the central wavelength for the specific filters used in the DRM programs.

**Figure 1:** The efficiency of the single surface coating. The new coating is labelled LLNL and the current coating is labelled MgF$_2$.

![Figure 1: Single Surface Coating Efficiency](image1)

**Figure 2:** The efficiency for the 3 surfaces coating. Labels as above.

![Figure 2: Three Surface Coating Efficiency](image2)
Calculations

We have computed the fractional variation of the signal-to-noise using the coating efficiency data and simple assumptions about the nature of the observations. Each program has been defined either as background limited or detector limited, according to the dominant source of noise. We computed the fractional variation in the signal to noise ratio caused by the change of the coating using the data shown in Figure 1 and 2, and the total exposure time of each DRM program.

To determine if a given program is background or detector limited, we assumed that there is a sub-exposure every 25 minutes to remove cosmic rays (i.e., NSPLIT or CRSPLIT), and that the useful portion of each orbit is 50 minutes long. The sky or background signal is computed from the product of the total exposure time and the known HST background. We considered two sources of detector noise: the dark current and the read out noise, but found that the dark current noise is always smaller than the read out noise. The fractional variation of the signal to noise ratio of both coating options, therefore, is simply:

\[
\Delta S_N = \frac{R_{LLNL}}{R_{MgF_2}} - 1
\]

where \(R_{LLNL}\) refers to the reflectivity for the proposed coating and \(R_{MgF_2}\) refers to the reflectivity for the current coating.

Subsequently, we computed the gain (or loss) in the number of orbits required to carry out the DRM programs as a result of the adoption of the new coating, keeping the signal to noise ratio of each observation constant. The number of orbits calculated for the new coating, for both the limiting cases is:

\[
Orbits_{new} = Orbits_{old} \frac{R_{MgF_2}}{R_{LLNL}}
\]

The results are shown in Figure 3 and 4, and summarized in Table 2.
Figure 3: The distribution of the change in the fractional variation of the signal to noise of the observations (i.e., N refers to the number of observations).

Figure 4: The distribution of the gained/lost orbits, using a bin size of 10, that results from changing the coating if the signal to noise of the DRM programs is held constant. The vertical scale does not show that the histograms peak at 131 and 113 observations, for the top and bottom respectively; it was adjusted to illustrate the details of the histograms.
Conclusion

The impact on the science programs of the DRM can be summarized as follows:

- The savings in exposure time is modest, only about 1.8% and 3.8% of the total DRM orbits for the 1 surface and 3 surfaces reflection, respectively. This corresponds to saving 172 and 357 orbits, respectively.
- The savings in exposure time for background-limited observations is 1.6% and 5.6%, or 145 and 523 orbits, respectively.
- The savings in exposure time for the detector-limited observations is 0.3% or 27 orbits for the single surface reflection. The loss in exposure time for detector-limited observations is 1.8% or 166 orbits for the 3 surfaces reflection.

The values in Table 1 give the number of orbits and observations that we have computed to be detector limited and background limited. Table 2 summarizes the results in terms of the number of orbits gained or lost and observations that gain or lose orbits.

Table 1. Summary of the DRM statistics, using the values for the current coating.

<table>
<thead>
<tr>
<th>DRM Statistics</th>
<th>Detector Limited</th>
<th>Background Limited</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Orbits</td>
<td>2162.5</td>
<td>7170.7</td>
<td>9333.2</td>
</tr>
<tr>
<td>Total Observations</td>
<td>55</td>
<td>125</td>
<td>180</td>
</tr>
</tbody>
</table>

Table 2. Summary of results for the new coating, based on Figure 3 and Figure 4.

<table>
<thead>
<tr>
<th>New Coating Results</th>
<th>Coating Applied to 1 Surface</th>
<th>Coating Applied to 3 Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbits gained</td>
<td>171.7 (1.8%)</td>
<td>522.5 (5.6%)</td>
</tr>
<tr>
<td>Orbits lost</td>
<td>0</td>
<td>165.8 (1.8%)</td>
</tr>
<tr>
<td>Total change in orbits</td>
<td>171.6 (1.8%) less orbits</td>
<td>356.7 (3.8%) less orbits</td>
</tr>
<tr>
<td>Number of observations that benefit</td>
<td>149</td>
<td>151</td>
</tr>
<tr>
<td>Number of observations that gain</td>
<td>31</td>
<td>29</td>
</tr>
</tbody>
</table>