The Canadian Space Agency is responsible for supplying the Fine Guidance Sensor (FGS) instrument to the James Webb Space Telescope (JWST) project. The FGS instrument uses three fields of view in the JWST focal plane to provide fine guidance for the telescope. In addition, it provides tunable filter (TF) capability for science in one of the fields. The dedicated guide channels are called FGS-G while the tunable filter channels are the FGS-TF. The field of view locations are chosen to provide optimum lever arms to all instruments for roll about a single guide star.

The FGS consists of an optical assembly and a set of Focal Plane / Instrument Control Electronics.

The optical assembly of the FGS instrument consists of two modules, each with two channels. The first (FGS-G) module images two separate regions of the sky onto two independent 2k x 2k focal plane arrays. The second (FGS-TF) module consists of a single FOV that is simultaneously imaged by two separate 2k x 2k focal plane arrays in two different wavelength regions via a dichroic beam-splitter. Each TF channel contains a filter wheel and tunable filter that allow flexible narrow-band imaging to be performed in the two simultaneous wavelength bands. Figure 1 shows a solid model of a preliminary optical design.

### Table 1: FGS Imaging Parameters

<table>
<thead>
<tr>
<th>Channel</th>
<th>FOV (arcsec)</th>
<th>Plate Scale (mas/pix)</th>
<th>Wavelength Range (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGS A</td>
<td>2.3'</td>
<td>68</td>
<td>0.8 - 2.5</td>
</tr>
<tr>
<td>FGS B</td>
<td>2.3'</td>
<td>68</td>
<td>0.8 - 2.5</td>
</tr>
<tr>
<td>Short TF</td>
<td>2.2'</td>
<td>65</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Long TF</td>
<td>65</td>
<td>65</td>
<td>2 - 4.8</td>
</tr>
</tbody>
</table>

**Figure 1:** FGS optical-mechanical model. Top: The FGS guider. Bottom: the FGS TF.
Table 1 summarizes the instrument imaging parameters. The TF wavelength ranges are preliminary.

The primary function of the FGS is to provide continuous pointing information to the Observatory that is used to stabilize the line of sight, allowing JWST to obtain the required image quality. Each of the independent FGS channels provide >95% probability of obtaining a useable guide star for any Observatory pointing. In fine guide mode the FGS will provide pointing information to a precision of <5 mas updated at 16 Hz. The wavelength region and pixel size (Table 1) have been optimized for this purpose.

The FGS is designed to be completely redundant in terms of the guiding function. The loss of any single component could, at the most, result in the loss of one FGS channel. This would reduce the probability of presently catalogued guide star acquisition to ~90%. However, the short wavelength TF channel provides a backup guiding capability that increases catalogued GS acquisition to >95%, even if one FGS module is lost. Figure 2 shows the modelled performance and GS availability.

The function of the FGS-TF is to provide JWST with a narrow-band imaging capability. The TF channel FOV was chosen to correspond to the NIRCam FOV (see Figure 1). With a spectral resolution of between 50 and 100 and the ability to continuously tune this passband over the range of wavelength shown in Table 1, FGS-TF provides JWST with a unique capability. A set of coronographic masks are incorporated near the TF pickoff mirror to allow observers to carry out spectrocoronagraphic observations of circumstellar disk companions and AGN host galaxies. The TF imaging and calibration is performed using via tunable Fabry-Perot filters and a ten-position filter wheel in each TF channel.

The TF sensitivity is estimated as about 200 rJy for S/N=10 in 10,000 sec and R=100 bandwidth.

![Figure 3: TF Science Examples](image)

Left: Lyman-dropout' galaxy detection should be possible out to z~17 (example shown above is a ground based detection at z~6). Such surveys will be done in conjunction with NIRCam.

Right: Coronography + Differential spectral imaging will allow extra-solar planet searches (example shown above is the detection of a brown dwarf by differential imaging, λ1 = 1.57 μm, λ2 = 1.625 μm and λ3 = 1.680 μm corresponding to continuum, & methane absorption respectively).

For further information, see
http://www.stsci.edu/jwst/instruments/guiders/ - the FGS page at STScI