The Development of an Analytical Model for the KODAK DIGITAL SCIENCE™ Color Infrared Cameras and Its Aerial Imaging Applications

Imaging Science MS Project
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Dedication:

This paper is dedicated to my loving wife, Debbie, and to my two great kids, Holly and Troy. My family has inspired and supported me throughout my academic career at RIT.

Abstract:

The new KODAK DIGITAL SCIENCE™ Color Infrared Cameras provide an affordable, high-resolution digital imaging solution for many low-altitude remote sensing applications. These remote sensing applications span forest management, law enforcement, environmental monitoring and agriculture crop analysis. This paper describes the technical aspects of the color infrared (CIR) cameras, and an analytical model of the cameras in aerial imaging scenarios. The model is based on physical attributes of the imaging chain and incorporates Modtran atmospheric data, measured ground target reflectance data, predicted aircraft motion, and measured/computed camera characteristics. It is capable of predicting both radiometric and image quality performance of a complete aerial image chain. Output data is in terms of 8-bit digital counts for the radiometric computations and ground resolving distance (GRD) for image quality analysis. normalized difference vegetation index (NDVI), for agriculture analysis, is also computed. The model is flexible and robust enough to predict over system performance in real life imaging scenarios or to be used as a design tool for camera optimization.

Table of Contents

1.0 BACKGROUND **1**

1.1 CIR CAMERA OVERVIEW 1
1.2 MODEL OVERVIEW 3

2.0 APPROACH **4**

3.0 TECHNICAL DESCRIPTION **6**

3.1 COLOR INFRARED CAMERA 6
3.2 MODEL DESCRIPTION 10
3.2.1 ATMOSPHERIC SECTION 10
3.2.2 GROUND TARGET SECTION 13
3.2.3 CAMERA SECTION 16
3.2.4 RADIOMETRIC MODEL EQUATIONS 19
3.2.5 IMAGE QUALITY MODEL EQUATIONS 24

4.0 RESULTS **30**

4.1 FLIGHT TEST DATA 30
4.2 MODELING CASE STUDY - THREE WHEAT CURVES 31

5.0 CONCLUSION / SUMMARY **35**

6.0 APPENDIX **37**

APPENDIX 1 - FLIGHT TEST IMAGE 38
APPENDIX 2 - NDVI IMAGE OF THE FLIGHT TEST IMAGE 40
APPENDIX 3 - RADIOMETRIC MODEL SAMPLE RUN 42
APPENDIX 4 - IMAGE QUALITY MODEL SAMPLE RUN 59
APPENDIX 5 - IMAGE PROCESSING DIAGRAM 70

7.0 REFERENCES **72**

List of Figures

FIGURE 1: SOLAR ENERGY PATH IN THE IMAGING CHAIN....................4
FIGURE 2: CCD SPECTRAL RESPONSE PLOT....................6
FIGURE 3: COLOR FILTER ARRAY (CFA) MADE BY KODAK....................7
FIGURE 4: COLOR FILTER ARRAY NORMALIZED TRANSMITTANCE PLOT....................7
FIGURE 5: INFRARED CAPTURE....................8
FIGURE 6: BAND-PASS FILTER TRANSMITTANCE PLOT....................9
FIGURE 7: EXOATMOSPHERIC SPECTRAL IRRADIANCE PLOT....................10
FIGURE 8: DOWNWELLED SOLAR RADIANCE PLOT....................11
FIGURE 9: UPWELLED SOLAR RADIANCE PLOT....................11
FIGURE 10: SUN TO TARGET ATMOSPHERIC TRANSMITTANCE PLOT....................12
FIGURE 11: TARGET TO SENSOR ATMOSPHERIC TRANSMITTANCE PLOT....................12
FIGURE 12: MACBETH COLORCHECKER CHART ROW #1 REFLECTANCE PLOT....................13
FIGURE 13: MACBETH COLORCHECKER CHART ROW #2 REFLECTANCE PLOT....................14
FIGURE 14: MACBETH COLORCHECKER CHART ROW #3 REFLECTANCE PLOT....................14
FIGURE 15: MACBETH COLORCHECKER CHART ROW#4 REFLECTANCE PLOT....................15
FIGURE 16: WHEAT REFLECTANCE PLOT....................15
FIGURE 17: 28 MM NIKON LENS TRANSMITTANCE PLOT....................16
FIGURE 18: 28 MM LENS FALL-OFF PLOT....................17
FIGURE 19: LENS MTF PLOT....................17
FIGURE 20: COLOR INTERPOLATION MTF PLOT....................18
FIGURE 21: AIRCRAFT MOTION MTF FOR VARIOUS INTEGRATION TIMES PLOT....................25
FIGURE 22: AIRCRAFT MOTION MTF FOR VARIOUS AIRCRAFT SPEEDS PLOT....................26
FIGURE 23: AIRCRAFT MOTION MTF FOR VARIOUS AIRCRAFT ALTITUDES PLOT....................26
FIGURE 24: DRIVER COMPARISON PLOT....................30
FIGURE 25: THE CIR CAMERA IMAGE PROCESSING DIAGRAM....................71

List of Tables

TABLE 1: WHEAT DIFFERENTIATION....................31
TABLE 2: LENS FALL-OFF AFFECT ON NDVI PREDICTIONS....................32
TABLE 3: ATMOSPHERIC IMPACT ON NDVI PREDICTIONS....................33
TABLE 4: WHEAT CASE-STUDY IMAGE QUALITY SUMMARY....................34

1.0 Background

1.1 CIR Camera Overview

The utilization of traditional infrared film photography for various applications has been well documented in many publications. Key current applications include forest management, law enforcement, environmental monitoring and agriculture crop analysis.

The KODAK DIGITAL SCIENCE™ Color Infrared Digital Cameras provide the benefits of infrared film along with a multitude of digital imaging benefits. Kodak currently offers two models of the infrared cameras. The KODAK DIGITAL SCIENCE™ 420 Color Infrared Camera and KODAK DIGITAL SCIENCE™ 460 Color Infrared Camera. The major difference between the two camera models is the size of the CCD imager. The 420 model has a 1.5 million pixel array incorporated into it while the 460 model utilizes a 6 million pixel imager.

The CIR digital cameras are not intended to replace the current 9 inch x 9 inch aerial infrared mapping films. The mapping films have superior resolution and orders of magnitude more area coverage capabilities than the current CIR cameras. For example, if a 9 inch x 9 inch piece of film was scanned at 9 µm x 9 µm pixel pitch with a dynamic range of 8 bits per color, the resulting image file size would be 1.9 GB. This is over 100 times larger than the image files from the 460 CIR camera. The 460 model produces a final file size of 18 MB per image.

The CIR camera and the infrared film essentially have the same spectral response. The spectral response of the CIR camera is slightly broader than the infrared film. The camera, with its silicon CCD, is sensitive from 400 nanometers (nm) to 1000 nm. The film's sensitivity falls between 400-900 nm. The 100 nm difference from 900 nm to 1000 nm is trivial for most aerial applications because of the H_2O absorption band in the atmosphere of between 900 nm and 1000 nm.

The benefits of the CIR cameras lies in their ability to produce reliable, repeatable images in a fraction of the time it would take to get the same results from traditional film. The output images from the digital camera are essentially instant. Some aerial photographers use the camera in conjunction with an on-board computer and view the imagery in-flight. The imagery from the CIR cameras are very consistent under the same capture conditions. This fact gives rise to the possibility of using the cameras as a radiometer for some remote sensing applications. In comparison, film radiometry is very difficult because of its roll-to-roll sensitometric variations.

A major revolution in remote sensing imagery is taking place. Over the next few years, electro-optical (E-O), multispectral high-resolution, commercial satellite imagery will be readily available to everyone. Currently, there is multispectral (MS) imagery available from satellite systems like Landsat and Spot. These systems produce MS imagery at 30 meter and 10 meter ground sample distance (GSD), respectively. Soon to be launched are high-resolution satellite systems like Space Imaging and EarthWatch. Both systems will provide MS imagery at 4 meter GSD.

There is no question that the new imaging satellites will compete with the aerial photography industry. The questions that still remains is how much, and how fast? Satellites have inherent system constraints that impact their ability to capture acceptable results. Some of the system constraints that must be considered include resolution, cloud-covered targets, and target revisit time. The new breed of commercial satellites will be resolution limited, by law, to 1 meter panchromatic GSD and 4 meter MS GSD or less. With this GSD constraint, objects smaller than 2 meters will not be resolvable. The new commercial E-O satellites have two other major limitations. First, they cannot image targets that are cloud covered. This means land mass that is primarily cloud covered will not be imaged by satellites very often. Secondly, satellites fly in specific elliptical orbits, which affects their ability to revisit specific targets at a specific resolution periodically. Targets will only be in view for a very short time, and only once a month or longer, until more satellites are deployed.

Aerial photography is not limited by these satellite constraints. Aircraft can achieve greater than 1 meter GSD. Depending on the urgency of the imagery, aircraft can fly under clouds and acquire images. Aircraft can fly over a target at the same resolution as necessary. This is a requirement for such applications as emergency rescue operations and some crop analysis projects.

1.2 Model Overview

The need for accurately predicting overall system performance is a must for today's imaging systems. No performance prediction model of the CIR camera exists. Also, there is no CIR camera optimization tool addressing the entire image chain. This paper presents an analytical CIR camera model that embodies the entire aerial imaging chain.

The focus of this paper is a detailed description of the model. In section 2, the approach of the model is presented. Section 3 is a technical description of all of the imaging chain components of the model and their interactions. Section 4 provides results of a modeling case study. The case study utilized three temporal states of wheat to show the robustness of the model and the CIR camera.. Also, output imagery of the camera is presented in empirical form. In section 5, conclusions, summaries and possible follow-on work is presented.

2.0 Approach

A systems approach to model the physical attributes of each part of the imaging chain has been adopted. The atmosphere, ground target, aircraft, CIR camera, and digital image processing (Adobe Photoshop plug-in drivers) make up the major components of the imaging chain in the model. The model consists of two separate spreadsheets. One spreadsheet predicts the 8-bit digital count output of the camera's radiometric response in the imaging chain. The second spreadsheet estimates image quality of the camera's output in the imaging chain. In order to make the model as accurate as possible, measured data was used when available. Such data includes target reflectance data, filter and lens performance data, and CCD responsivity data. The details of the measured data are presented in section 3.

The radiometric model uses only reflected energy (no self-emission energy) throughout the imaging chain. Figure 1 depicts the solar energy path, as modeled in the radiometric model. Solar-ray "A" represents the exoatmospheric spectral irradiance. Solar-ray "B" represents the downwelled solar radiance. Solar-ray "C" represents the upwelled solar radiance[13].

The atmosphere is modeled by incorporating Modtran data into it. The model assumes a lambertian (no angular dependence) ground target and no spectral shift with a change in solar zenith angle. Output of the radiometric analysis is in terms of 8-bit digital counts for a particular pixel .

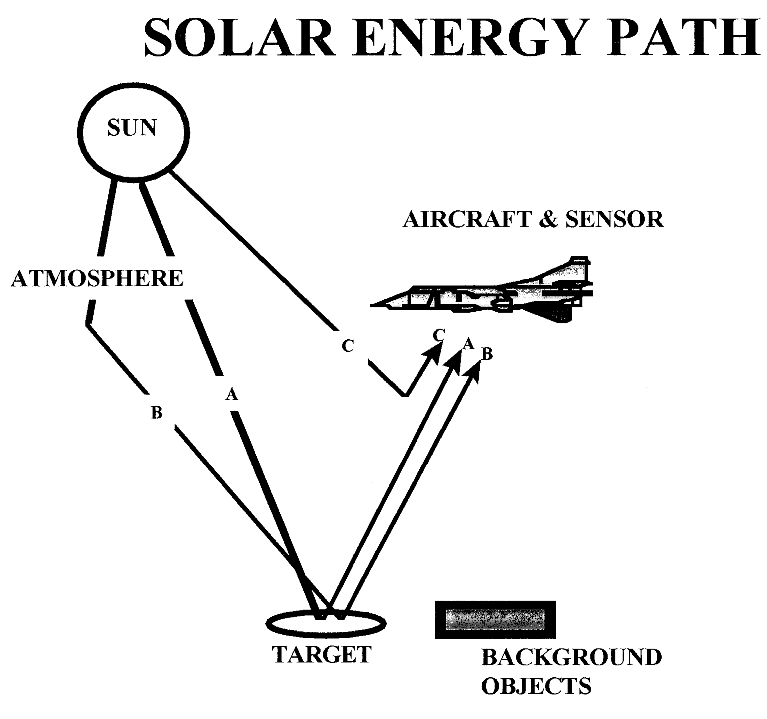


Figure 1: Solar Energy Path in the Imaging Chain

The image quality model is based on threshold modulation analysis (TMA)[9]. TMA compares the input or available modulation (ITM) to the required or needed modulation (TM) to predict an overall performance. The comparison between the input and required modulations can take place at any part in the imaging chain. The image quality model compares the two modulations at the focal plane. The image quality model uses data computed from the radiometric model (signal electrons, noise electrons, and the NDVI) as input for the noise modulation and target contrast calculations. The model assumes a linear system such that individual modulation transfer functions (MTF) can be cascaded together to predict overall input and required ITM. Both in-track and cross-track MTFs are computed and analyzed. The final output of the image quality portion is ground resolving distance (GRD) for a specific colored pixel.

3.0 Technical Description

3.1 Color Infrared Camera

The color infrared cameras are derivatives of the KODAK PROFESSIONAL DCS Digital Cameras. Both the CIR and the Professional DCS cameras have silicon CCDs. To achieve three-channel information, the CCDs utilizes a color filter array (CFA), "Bayer pattern" design[1,3,8]. The CFA protocol is 25% of the total pixels are red, 50% are green, and 25% are blue. Like most silicon CCDs, the Kodak cameras' CCDs are responsive from 400 nm to 1000 nm. The quantum efficiency (QE) curve of the 460 model's CCD is shown below in Figure 2.[6]

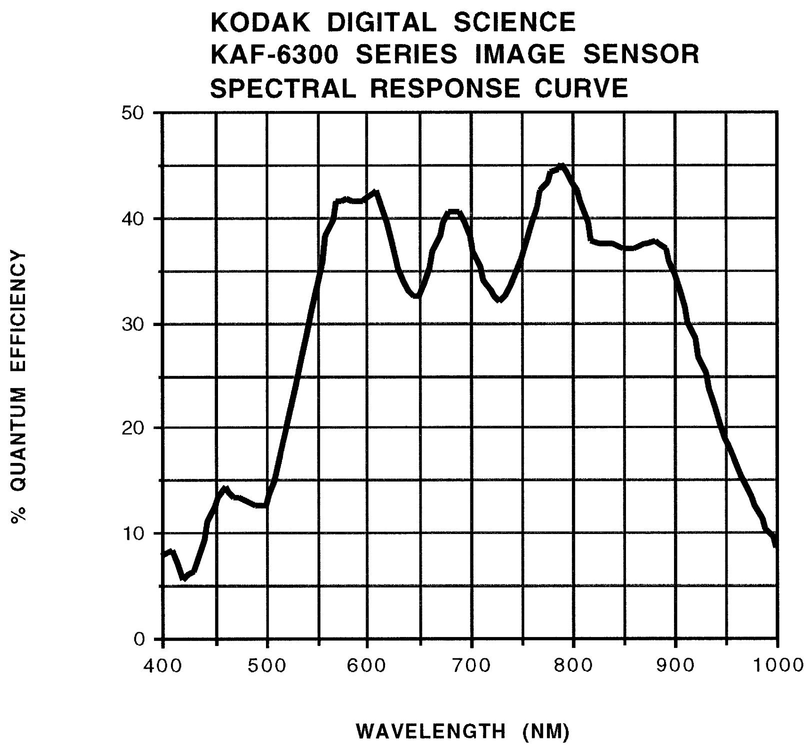


Figure 2: CCD Spectral Response Plot

The QE for the 420 camera is essentially the same. The Bayer pattern CFA of the CCD for the 460 camera is shown below in Figure 3.[8]

G	B	G	B	G	B	....	G	B	G	B
R	G	R	G	R	G	....	R	G	R	G
G	B	G	B	G	B	....	G	B	G	B
R	G	R	G	R	G	....	R	G	R	G
G	B	G	B	G	B	....	G	B	G	B
R	G	R	G	R	G	....	R	G	R	G
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
G	B	G	B	G	B	....	G	B	G	B
R	G	R	G	R	G	....	R	G	R	G
G	B	G	B	G	B	....	G	B	G	B
R	G	R	G	R	G	....	R	G	R	G

R - red pixels
G - green pixels
B - blue pixels

Figure 3: Color Filter Array (CFA) made by KODAK

As shown in Figure 4, the unique dye layers of the CFA are not only transmissive in their respective color-band, but also in the near-infrared region. It is this transmissive fact that makes the CIR version of the cameras possible. Note these curves are normalized to 80% peak in the model.

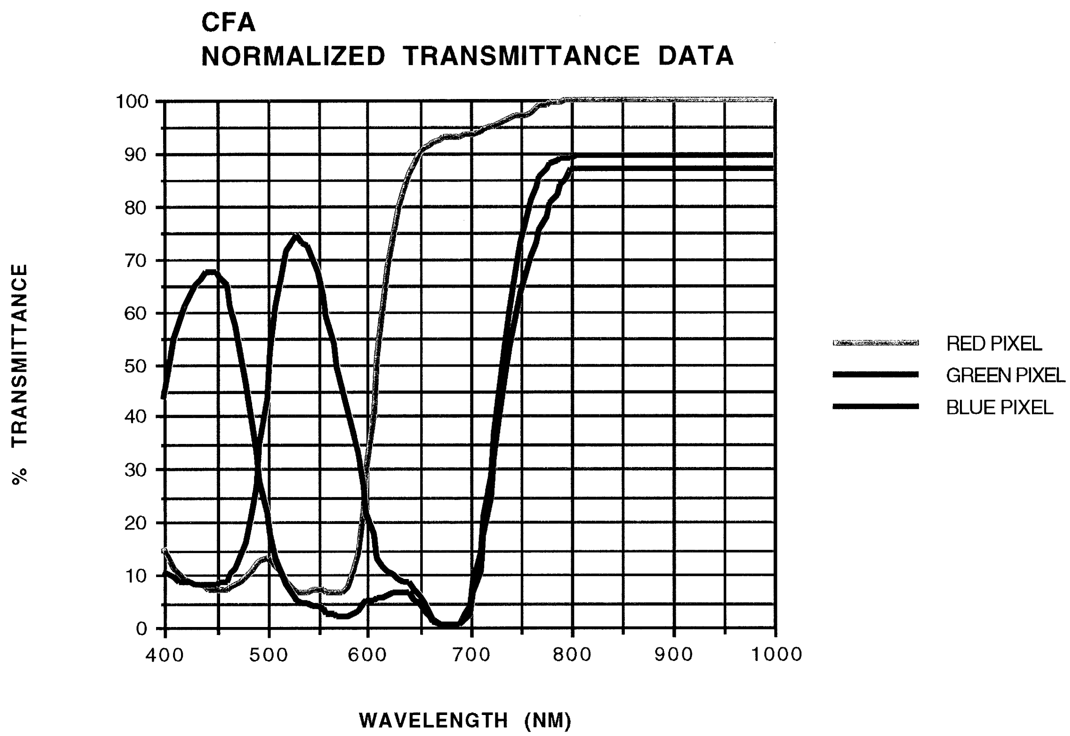


Figure 4: Color Filter Array Normalized Transmittance Plot

Color Infrared Capture

The diagram below illustrates the entire color infrared capturing process.

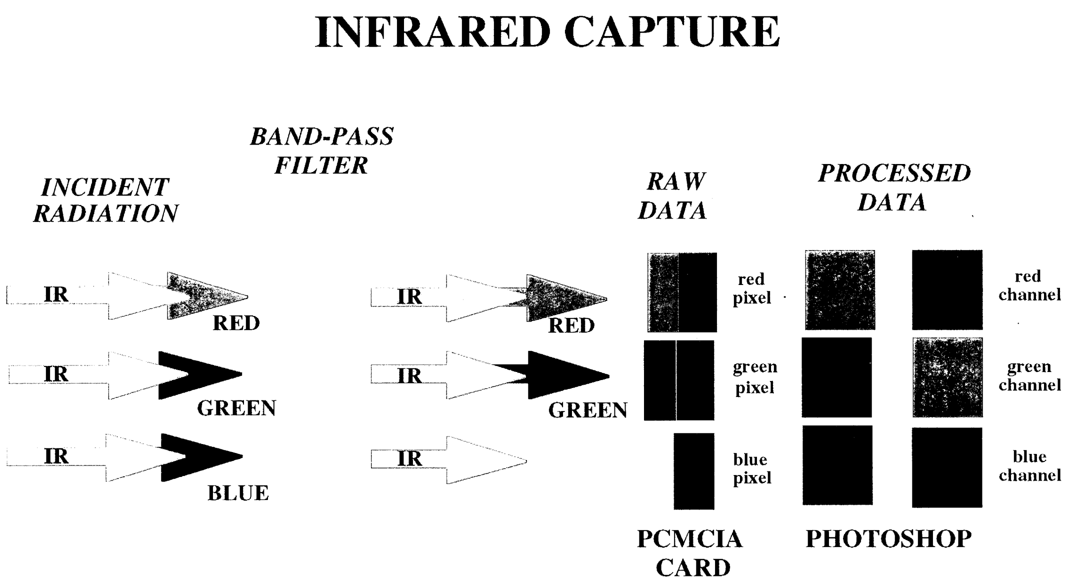


Figure 5: Infrared Capture

In order to use the CFA to capture near-infrared radiation, three major differences between the CIR and the generic Professional DCS cameras are required. These differences include the cover-glass on the charge coupled device (CCD), the lens band-pass filters, and image-processing software used to view the images. The CIR cameras are manufactured with a so-called clear cover glass, which allows infrared radiation to penetrate to the collecting portion of the CCD. The Professional DCS camera versions have IR attenuating cover glass on it.

The CIR cameras come with two distinct band-pass filters that screw on the front of the Nikon lenses.[6] The 650BP300 is used for near-infrared imaging and has a band-pass from 500 nm to 800 nm. The VIS filter is used to acquire natural color images from the CIR camera. Figure 6 shows the measured transmittance of the two CIR camera filters.

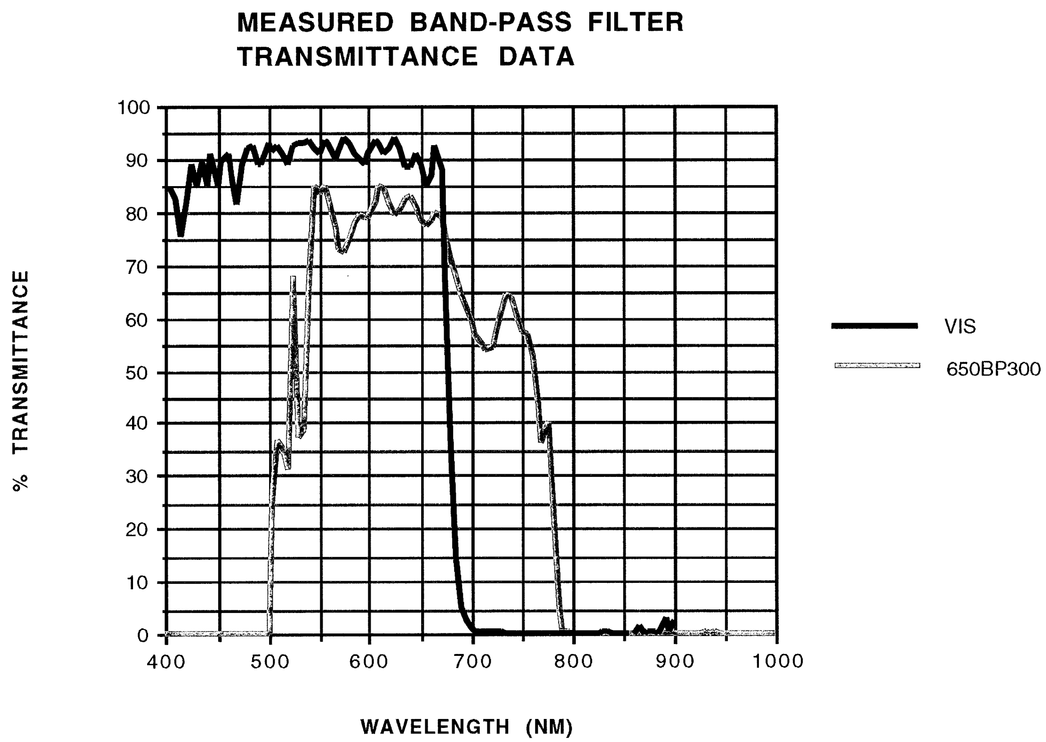


Figure 6: Band-pass Filter Transmittance Plot

The last major camera difference is found in the image-processing software. Both camera versions' software interpolates the raw color data to effectively give each pixel in the final image full, 24-bit color. In addition to the interpolation algorithms, the CIR driver backs-out the IR signal from the total signal captured by the red and green pixels, performs a color balance, and applies a false color registration. Therefore, the final infrared RGB image in file has the infrared signal in the red channel, the red signal in the green channel, and the green signal in the blue channel. This false color reassignment is the same assignment found in infrared film.

CIR Camera Specifications[6]

The following is a summary of the key CIR camera specifications:

Camera Body: Nikon N90

Pixel Size:	9 µm x 9 µm
Resolution(in pixel):	1012 x 1525 (420 model); 2056 x 3060 (460 model)
Spectral sensitivity:	400 nm - 1000 nm (no Filter)
	400 nm - 700 nm (with VIS Filter)
	500 nm - 800 nm (with IR Filter)
Dynamic Range:	36-bit color capture; 24-bit color stored
File Size:	4.5 MB (420 model); 18 MB (460 model)

3.2 Model Description

3.2.1 Atmospheric Section

Currently, the model has three different atmospheric options incorporated into it. All of the atmospheres have been generated using the USAF Modtran atmospheric model. Currently, the radiometric model's atmospheric options, are all Northeastern United States summer day models. The difference between the atmospheres is the amount of overcast and humidity in them. The three atmospheres are:

1) Clear summer day with 23 km visibility (Roch-23)
2) Summer day with 7 km visibility (Roch-7)
3) Summer day with only 5 km visibility and an additional 50% humidity added (Roch-5+).

The following five figures are plots of the Modtran out data from the three different atmospheres runs. Figure 7 is a plot of the three atmospheres exoatmospheric spectral irradiance. Figure 8 shows the downwelled solar radiance for the atmospheres. Figure 9 shows the upwelled solar radiance. Figures 10 and 11 are the atmospheric transmittance plots for the three atmospheres. Figure 10 displays the sun to target atmospheric transmittance and Figure 11 displays the target to sensor atmospheric transmittance.

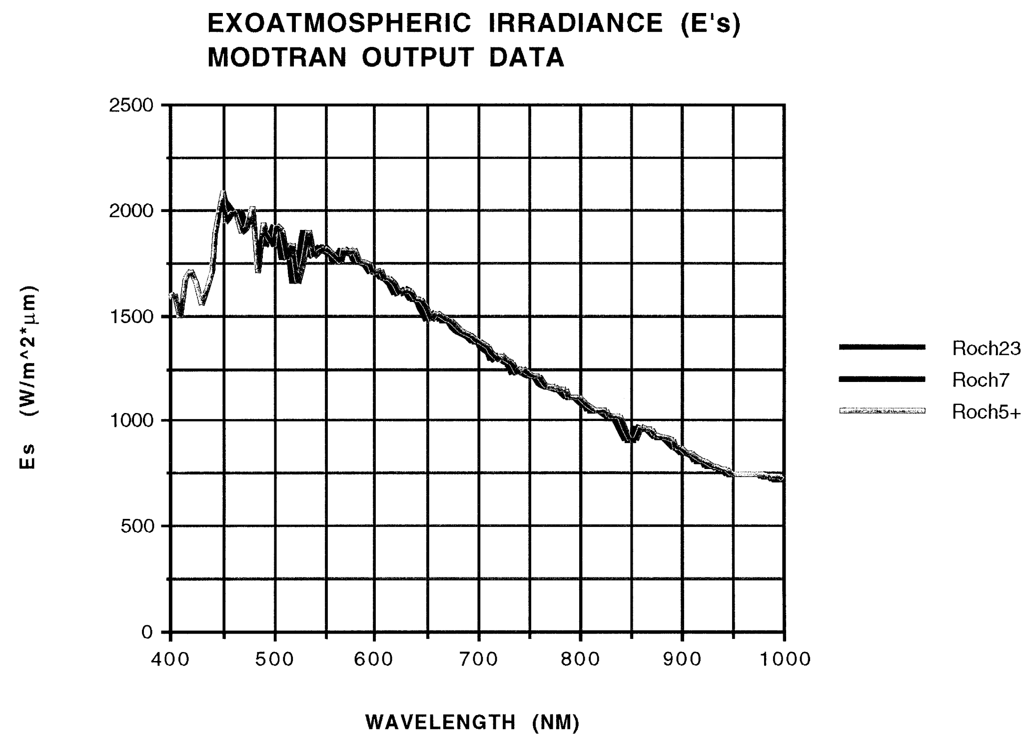


Figure 7: Exoatmospheric Spectral Irradiance Plot

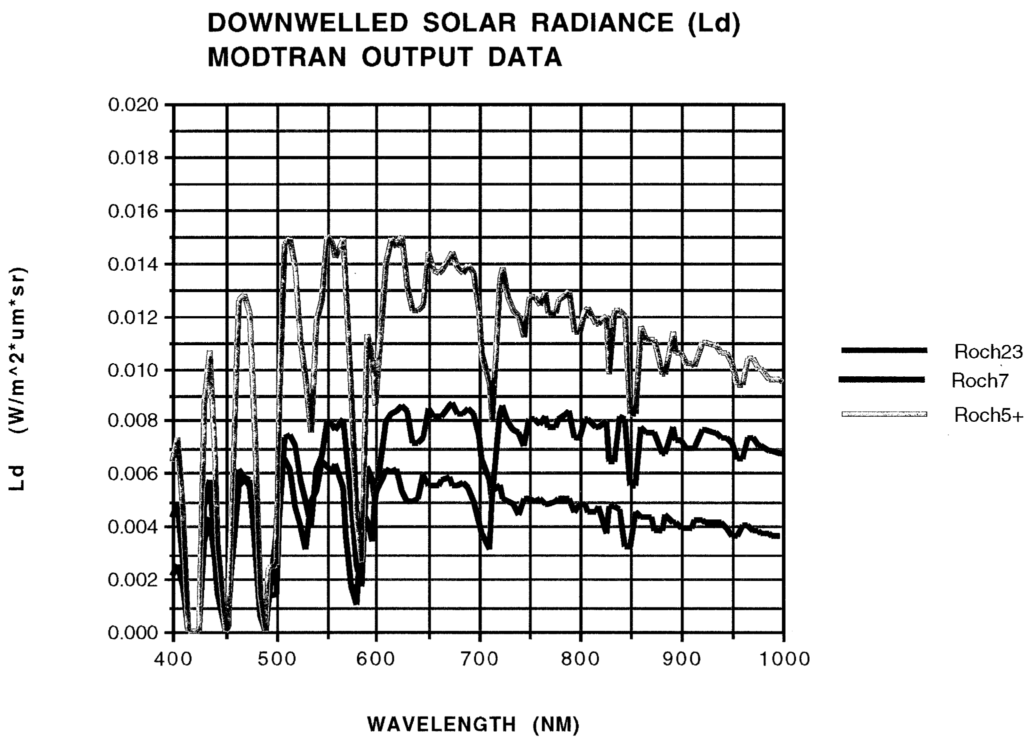


Figure 8: Downwelled Solar Radiance Plot

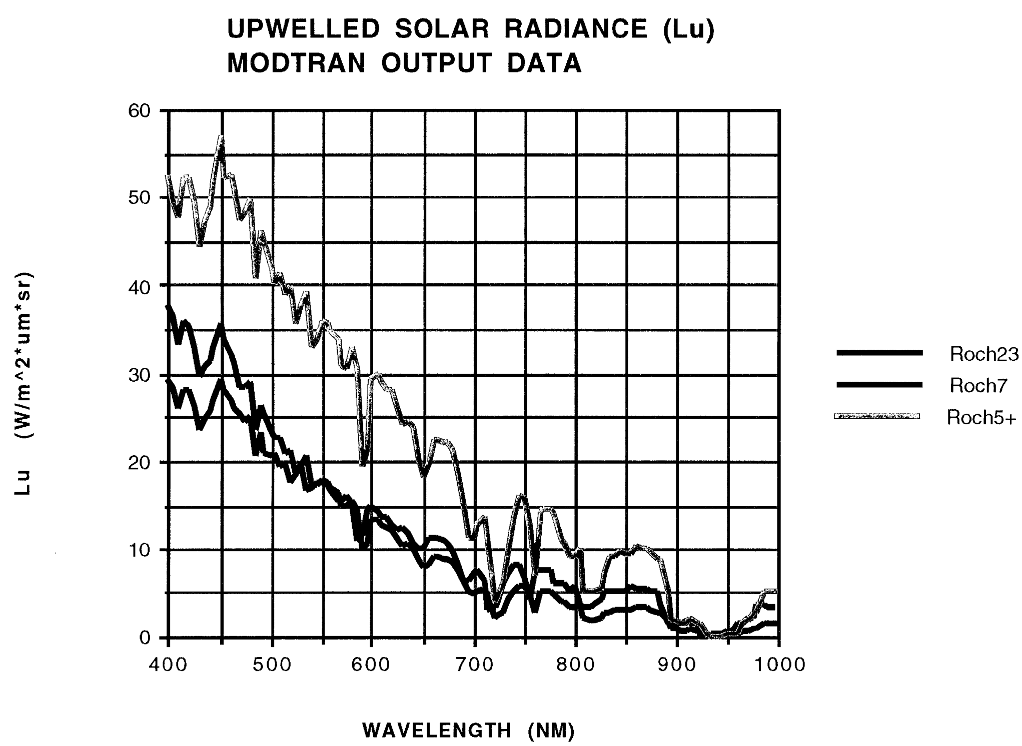


Figure 9: Upwelled Solar Radiance Plot

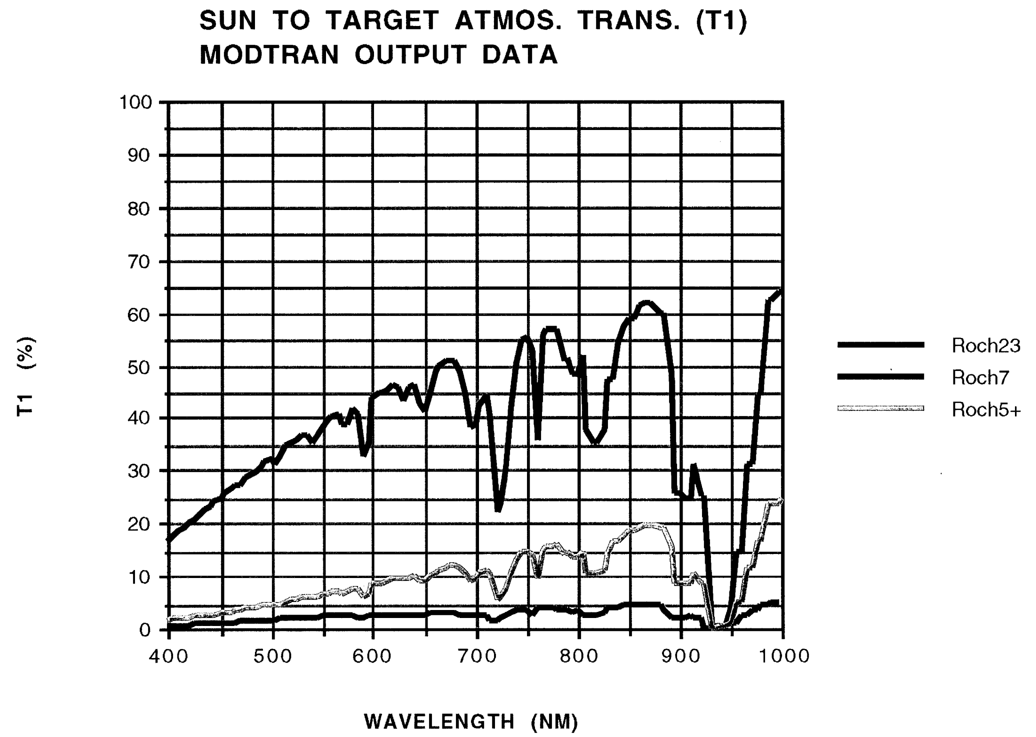


Figure 10: Sun to Target Atmospheric Transmittance Plot

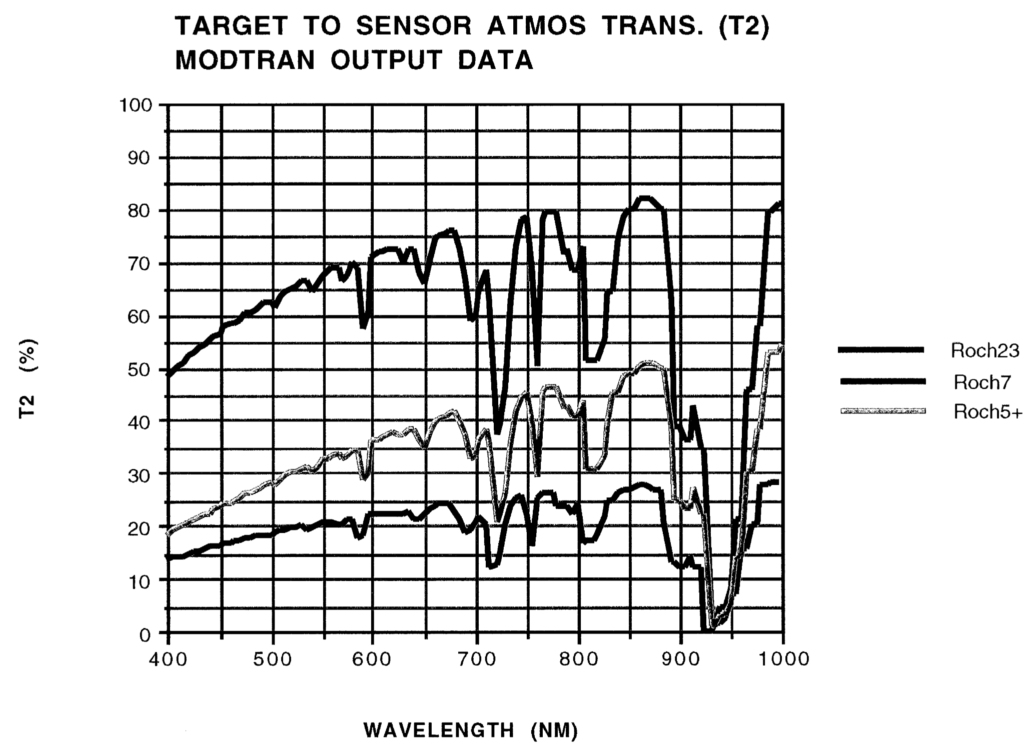


Figure 11: Target to Sensor Atmospheric Transmittance Plot

3.2.2 Ground Target Section

The model currently incorporates two main target source options, one man-made target and one natural target. The two targets are the Macbeth Colorchecker chart and Wheat reflectance data. The spectral reflectances of the targets were accurately measured between 400 nm and 1000 nm at 5 nm increments.

The Macbeth color checker is a well-known color standard used in the graphic arts and publishing industry. The Colorchecker consists of twenty-four different color patches. The patches consist of both a variety of colors and neutral gray levels. The Colorchecker typically comes in an oversize of 9 by 13 inches with individual patches of 1.75 by 1.75 inches. In 1996, Kodak contracted Macbeth a create a Colorchecker that has 1 meter by 1 meter size color patches and 2 meter by 2 meter gray patches. This mammoth version of the Colorchecker is for ground-truth analysis for aerial imaging. Figures 12 through 15 show the measured reflectances of the various patches.

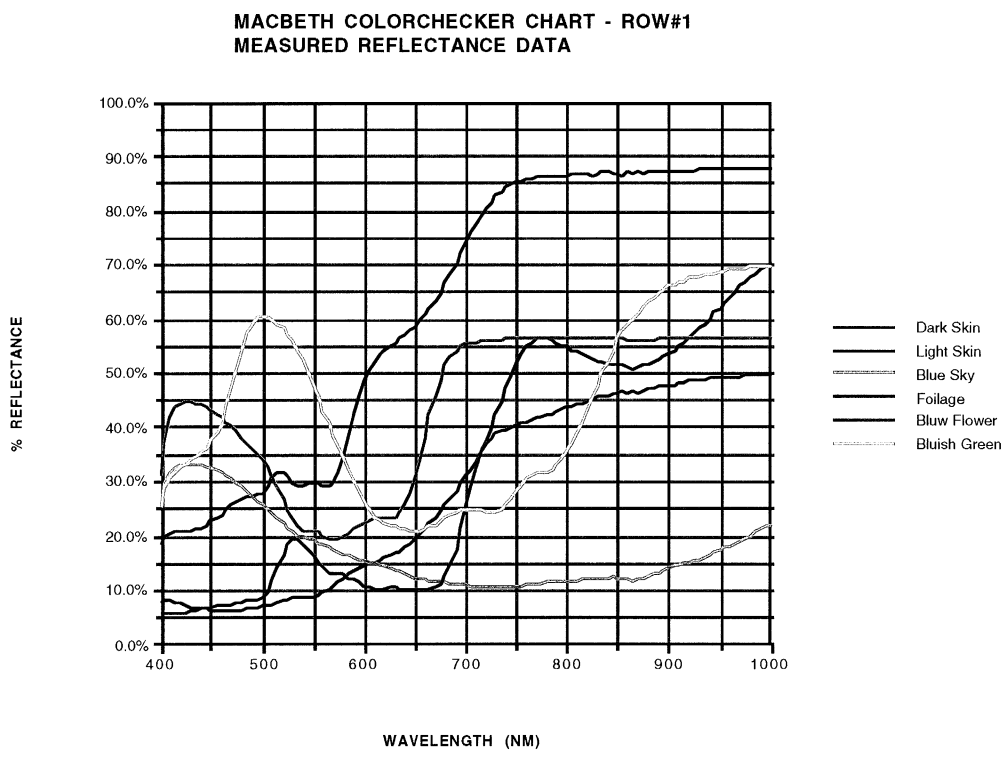


Figure 12: Macbeth Colorchecker Chart Row #1 Reflectance Plot

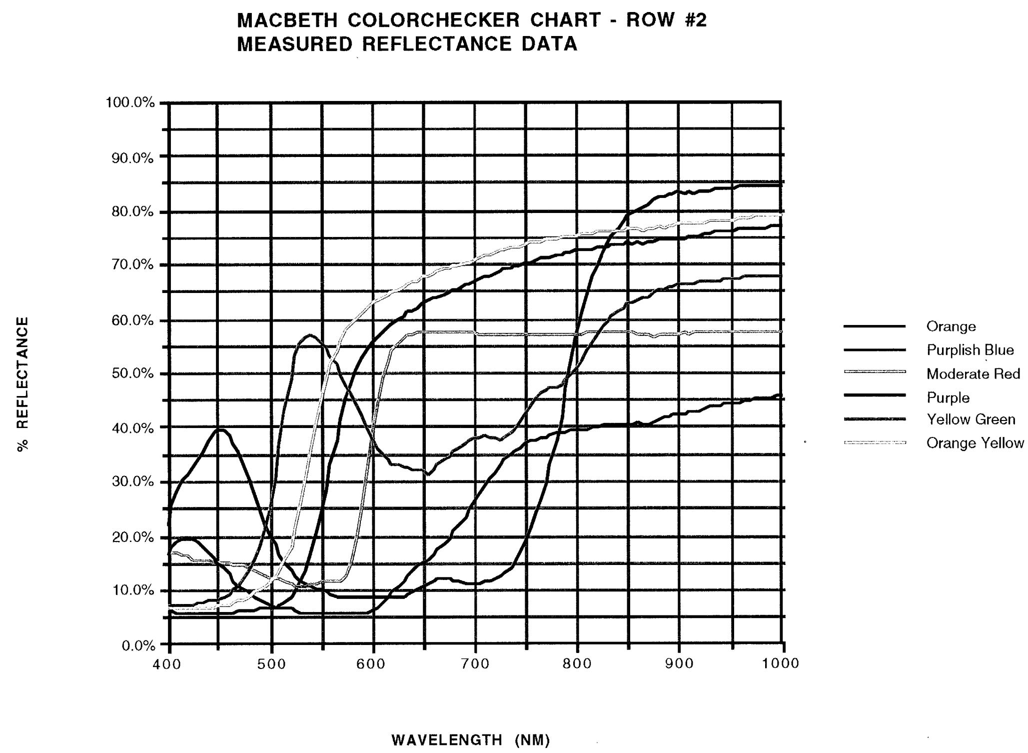


Figure 13: Macbeth Colorchecker Chart Row #2 Reflectance Plot

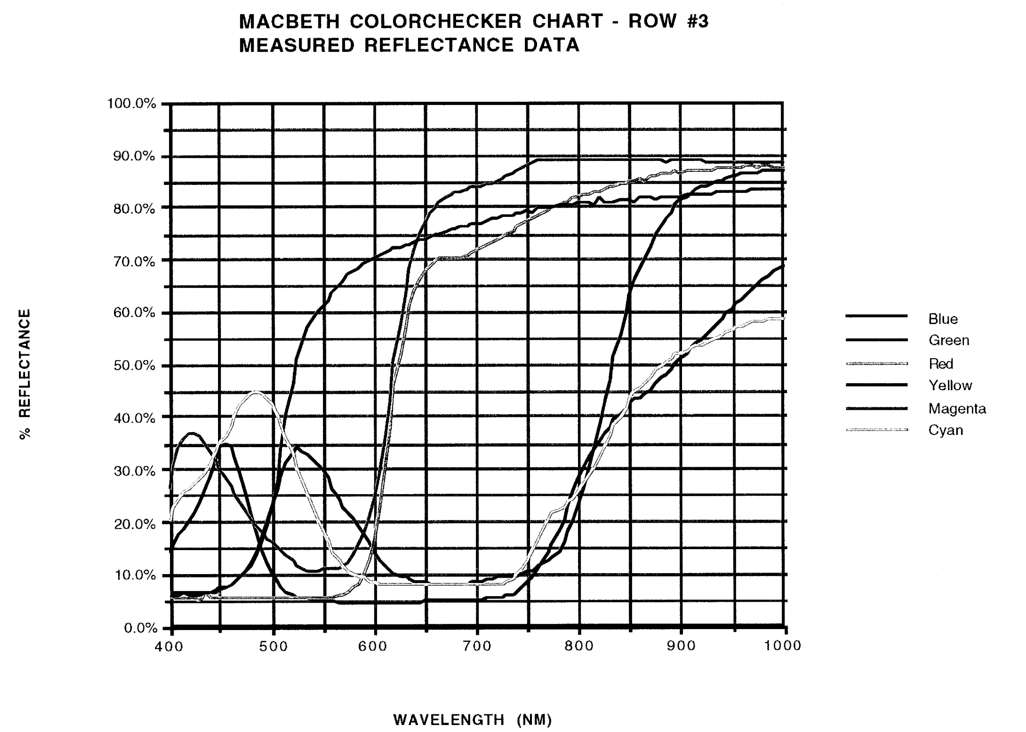


Figure 14: Macbeth Colorchecker Chart Row #3 Reflectance Plot

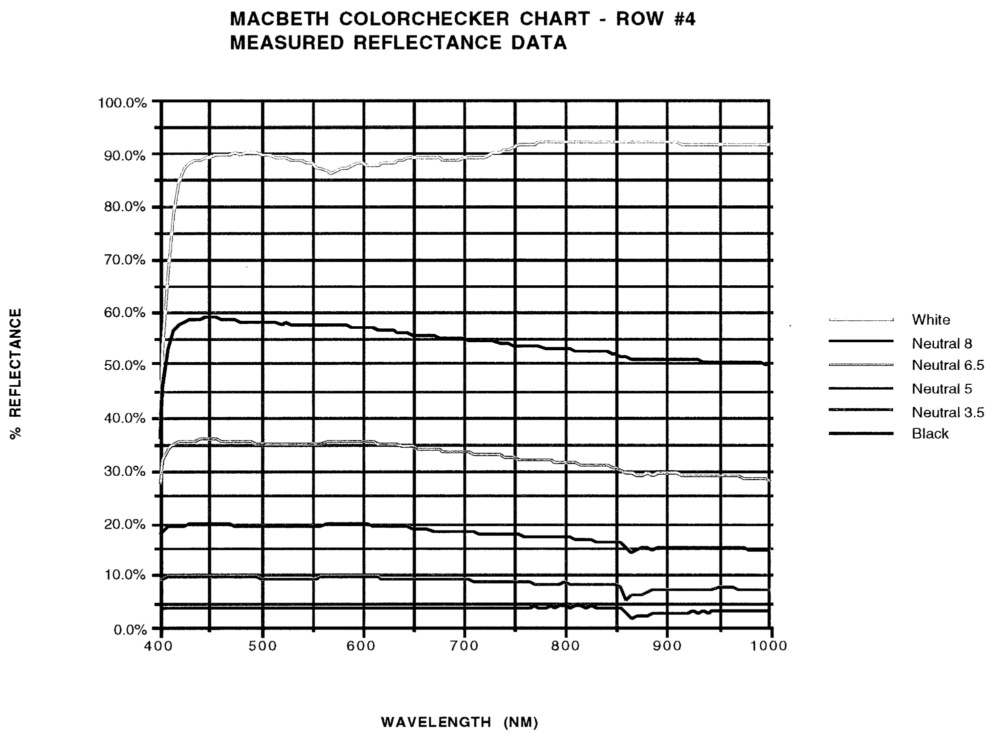


Figure 15: Macbeth Colorchecker Chart Row #4 Reflectance Plot

The second target spectra, measured wheat reflectance data, is composed of three stages of annual wheat growth. The reflectance curves of the three stages of growth are shown below in Figure 16.

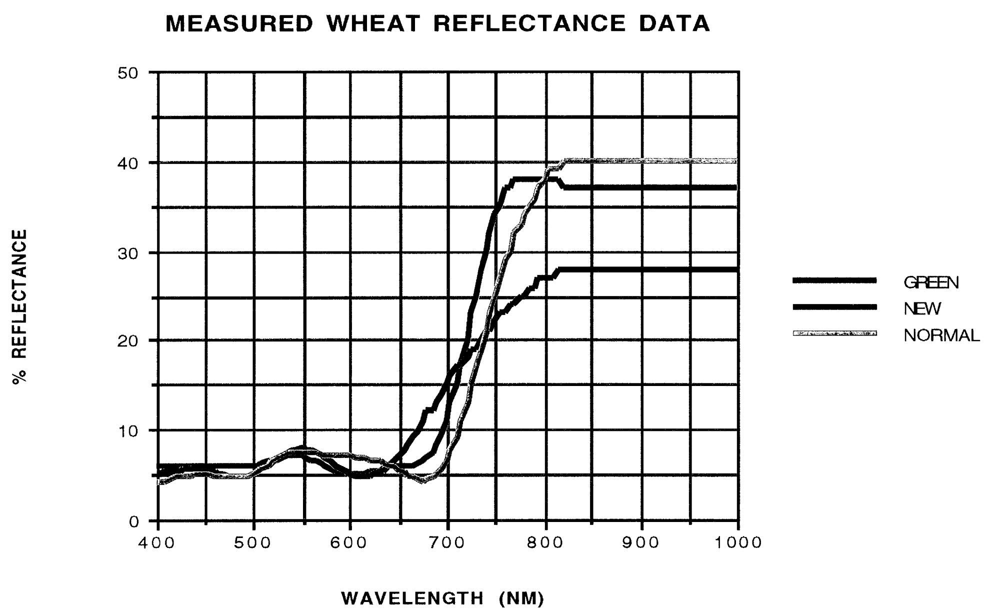


Figure 16: Wheat Reflectance Plot

3.2.3 Camera Section

The major technical characteristics of the CIR cameras have already been discussed. For completeness, a few remaining radiometric modeling considerations of the camera must still be addressed. The transmittance of the camera's lens must be incorporated into the radiometric model. The spectral transmittance of a 28 mm Nikon Nikkor lens was measured, and the data is shown in Figure 17 below. (Note, the anomaly around 875 nm is due to the spectrometer.)

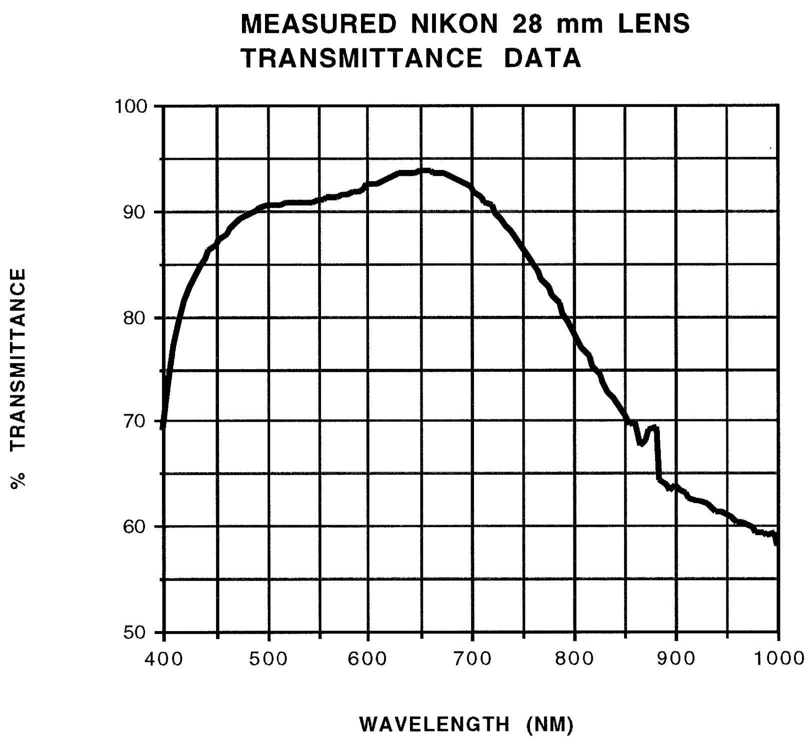


Figure 17: 28 mm Nikon Lens Transmittance Plot

The lens fall-off (fall-off of intensity as a function of field angle) was also measured and incorporated into the model by using a average COS^3 and COS^4 function (see Figure 18). This roll-off factor is important in comparing on-axis data to off-axis data. Since the 460 camera has a significantly larger field than the 420 version, the lens roll-off will have a much larger impact in final performance. As shown below in Figure 18, the 460 camera's energy falls off substantially out in the field. The model uses a LUT for lens roll-off prediction. Currently, the model assumes a lens focal length of 28 mm and is capable of predicting on-axis, half-field, and full-field point radiometric performance.

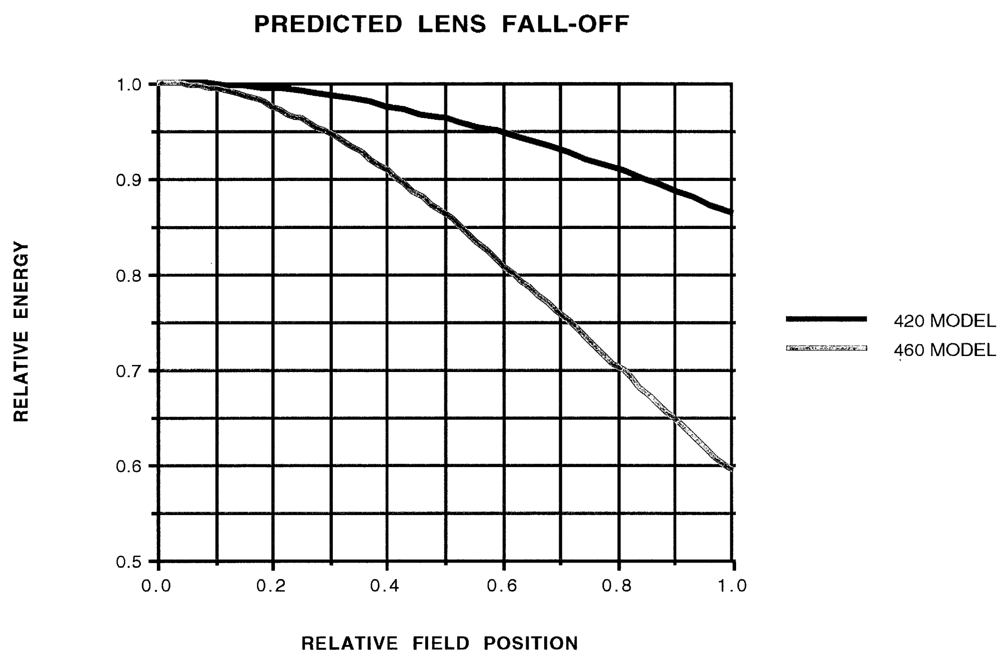


Figure 18: 28 mm Lens Fall-Off Plot

Figure 19 shows the Lens MTF of the Nikon 28 mm lens. The Nikon lens was measured with the 650BP300 band-pass filter screwed onto it. This data was taken at half-field in the radial direction. The focus position was kept at the on-axis best focus point. The top curve is the F/5.6 diffraction limited lens[14]. Notice that the Nikon lens is far from being diffraction limited. This lens is typical for off-the-shelf consumer lenses.

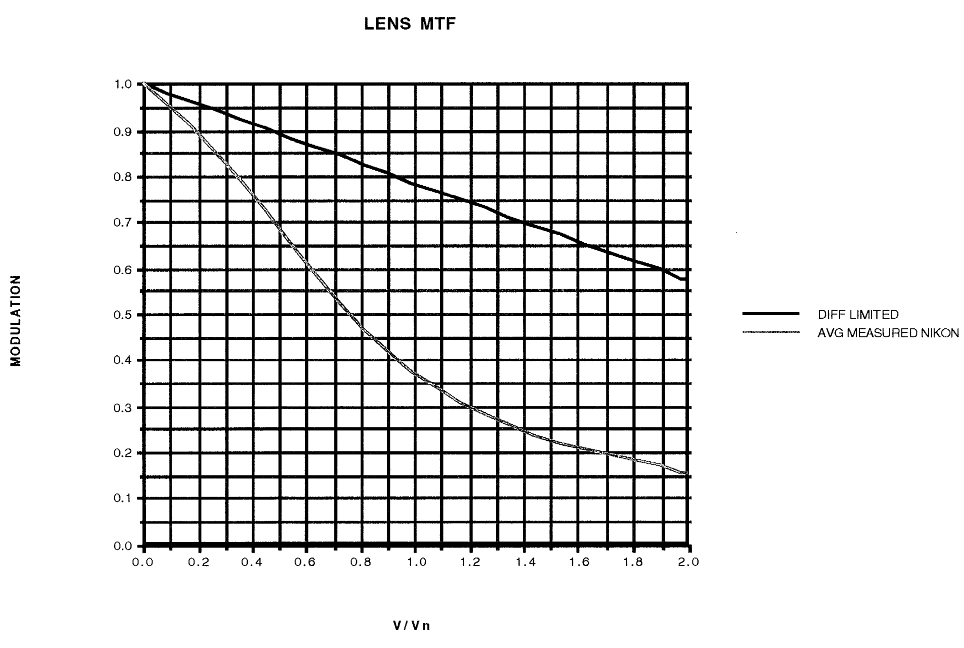


Figure 19: Lens MTF Plot

Figure 20 shows the driver interpolation MTF for the three color pixels. The interpolation MTF is a result of the Bayer pattern architecture[1]. The interpolation MTF is scene dependent and is therefore modeled as a weighted average MTF. The red pixel and blue pixel MTFs are identical. Note, the red and blue pixels are intrinsically influenced by the green pixel. The resulting MTF curves are clearly color distinct. Because of this MTF color distinction, some images will suffer from color aliasing of some objects. The presence of color aliasing can be seen in Table 4 of the Results section of this paper .

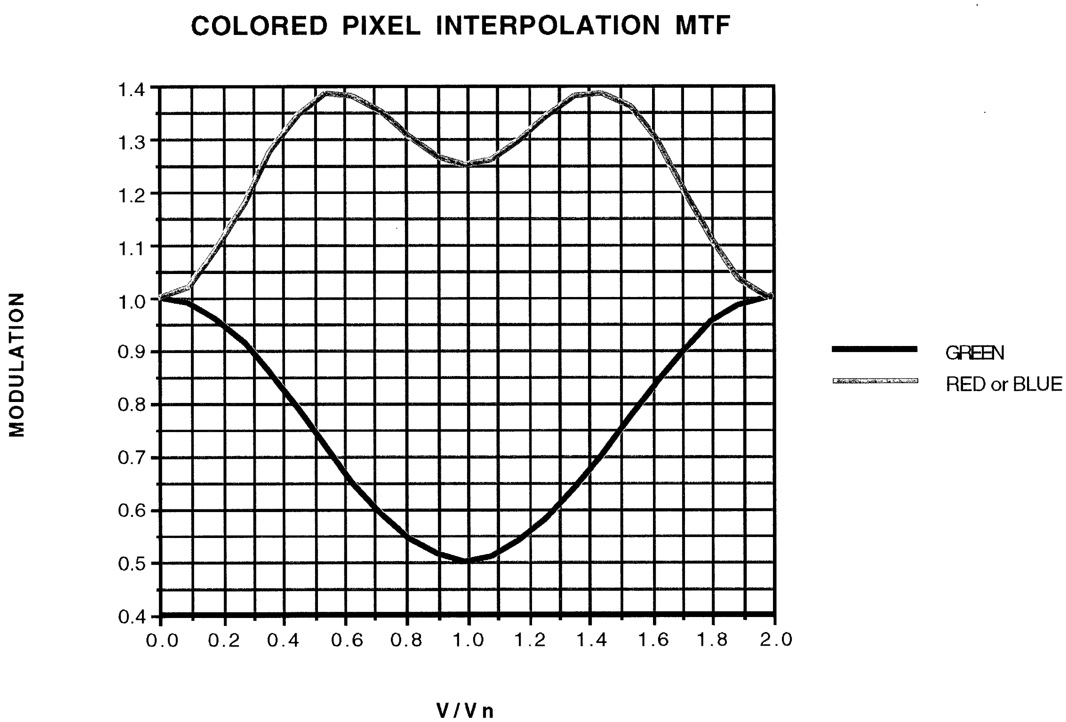


Figure 20: Color Interpolation MTF Plot

3.2.4 Radiometric Model Equations

The following two sub-sections (3.2.4 and 3.2.5) rigorously define and detail the equations used in the model. Sub-sections 3.2.4 concentrates on the equations used in the radiometric portion of the model. The main reference sources for these equations are: Schott[13], Dereniak and Crowe[4], Boyd[2], and Ekiert[9]. These equations analytically describe the radiometric attributes of the entire imaging chain (from the sun's radiation to the target's reflectance to the camera's digital count output).

Total spectral solar radiance reaching the front of the sensor[13]: $L_{sensor\text{-}frt}$ [watts / (meter^2 * micron * steradian)]

$$L_{sensor\text{-}frt}(\lambda) = E'_s(\lambda) * \tau_1(\lambda) * \cos(\sigma) * (r(\lambda)/\pi) * \tau_2(\lambda) + \tau_2(\lambda) * r(\lambda) * L_d(\lambda) + L_u(\lambda) \quad (R1)$$

where:

$E'_s(\lambda)$ is the exoatmospheric irradiance [watts / (meter^2 * micron)]

$\tau_1(\lambda)$ is the atmospheric spectral transmittance along the sun to target path [%]

σ is the solar zenith angle [degrees]

$r(\lambda)$ is the target spectral reflectance [%]

$\tau_2(\lambda)$ is the atmospheric spectral transmittance along the target to sensor path [%]

$L_d(\lambda)$ is the downwelled solar radiance [watts / (meter^2 * micron * steradian)]

$L_u(\lambda)$ is the path solar radiance [watts / (meter^2 * micron * steradian)]

-or - the total spectral solar radiance reaching the front of the sensor can be expressed in terms of its signal and haze components:

$$L_{sensor\text{-}frt}(\lambda) = L_{sensor\text{-}frt,signal}(\lambda) + L_{sensor\text{-}frt,haze}(\lambda) \quad (R2)$$

where:

$$L_{sensor\text{-}frt,signal}(\lambda) = E'_s(\lambda) * \tau_1(\lambda) * \cos(\sigma) * (r(\lambda)/\pi) * \tau_2(\lambda) + \tau_2(\lambda) * r(\lambda) * L_d(\lambda)$$

$$L_{sensor\text{-}frt,haze}(\lambda) = L_u(\lambda)$$

Total irradiance at the detector (or pixel)[2,4,13]; $E_{e,det}(\lambda)$ [watts / (meter^2 * micron)]

$$E_{e,det}(\lambda) = \pi * L_{sensor\text{-}frt}(\lambda) * T_{bpf}(\lambda) * T_{lens}(\lambda) / ((4 * F/\#^2)+1) \quad (R3)$$

where:

$L_{sensor\text{-}frt}(\lambda)$ is the total spectral radiance reaching the front of the sensor
T_{bpf} is the spectral transmittance of the band-pass filter in front of the lens [%]
T_{lens} is the spectral transmittance of the lens [%]
F/# is F number of the lens = focal length / entrance pupil diameter

- or - the total irradiance at the detector (or pixel); can be expressed in terms of its signal and haze components:

$$E_{e,det}(\lambda) = E_{e,det,signal}(\lambda) + E_{e,det,haze}(\lambda) \qquad (R4)$$

where:

$$E_{e,det,signal}(\lambda) = \pi * L_{sensor\text{-}frt,signal}(\lambda) * T_{bpf}(\lambda) * T_{lens}(\lambda) / ((4 * F/\#^2) + 1)$$
$$E_{e,det,haze}(\lambda) = \pi * L_{sensor\text{-}frt,haze}(\lambda) * T_{bpf}(\lambda) * T_{lens}(\lambda) / ((4 * F/\#^{2)} + 1)$$

Total irradiance at the detector (or pixel)[4]; $E_{p,det}(\lambda)$ [photons / (meter^2 * micron * second)]

$$E_{p,det}(\lambda) = E_{e,det}(\lambda) * \lambda/(h * c) \qquad (R5)$$

where:

λ = emitted photon wavelength [microns]
h = Planck's constant (6.6262×10^{-34} Wsec^2)
c = speed of light (2.999×10^8 m/sec)

-or-

$$E_{p,det}(\lambda) = E_{p,det,signal} + E_{p,det,haze} \qquad (R6)$$

where:

$$E_{p,det,signal}(\lambda) = E_{e,det,signal}(\lambda) * \lambda/(h * c)$$
$$E_{p,det,haze}(\lambda) = E_{e,det,haze}(\lambda) * \lambda/(h * c)$$

Total electrons due to solar radiation for a given wavelength; e_{num} [electrons]

$$e_{num}(\lambda) = E_{p,det}(\lambda) * \eta(\lambda) * A_{det} \qquad (R7)$$

where:

$E_{p,det}(\lambda)$ [photons / (meter^2 * micron * second)]
$\eta(\lambda)$ is the quantum efficiency of the detector [%]
A_{det} is the area of the detector or pixel [meter^2]

-or-

$$e_{num}(\lambda) = e_{num,signal}(\lambda) + e_{num,haze}(\lambda) \quad \text{(R8)}$$

where:

$$e_{num,signal}(\lambda) = E_{p,det,signal}(\lambda) * \eta(\lambda) * A_{det}$$
$$e_{num,haze}(\lambda) = E_{p,det,haze}(\lambda) * \eta(\lambda) * A_{det}$$

Total electrons due to solar radiation for a given wavelength band; $e_{num,wb}$ [electrons]

$$e_{num,wb}(\lambda) = e_{num}(\lambda) * \Delta_\lambda \quad \text{(R9)}$$

where:

$e_{num}(\lambda)$ is the number of electrons for a given wavelength
Δ_λ is the wavelength bandwidth [microns]

-or-

$$e_{num,wb}(\lambda) = e_{num,wb,signal}(\lambda) + e_{num,wb,haze}(\lambda) \quad \text{(R10)}$$

where:

$$e_{num,wb,signal}(\lambda) = e_{num,signal}(\lambda) * \Delta_\lambda$$
$$e_{num,wb,haze}(\lambda) = e_{num,haze}(\lambda) * \Delta_\lambda$$

Total number of electrons at the detector or pixel due to solar radiation; e_{det} [electrons]

$e_{det} = \sum e_{num,wb}(\lambda)$; summed over the defined wavelength band (R11)

-or-

$$e_{det} = \sum (e_{num,wb,signal}(\lambda) + e_{num,wb,haze}(\lambda)) \quad \text{(R12)}$$

Total number of electrons for a monochrome pixel; $e_{det,m}$ [electrons]

$e_{det,m} = e_{det}$ -or- (R13)

$$e_{det,m} = e_{det,m,signal} + e_{det,m,haze} \quad \text{(R14)}$$

Total number of electrons for a red pixel due to solar radiation; $e_{det,r}$ [electrons]

$e_{det,r} = \Sigma (T_{cfa,r}(\lambda) * e_{num,wb}(\lambda))$; summed over the defined wavelength band (R15)

where:

$T_{cfa,r}(\lambda)$ is the color filter array red pixel spectral transmittance [%]

-or-

$e_{det,r} = e_{det,r,signal} + e_{det,r,haze}$ (R16)

where:

$e_{det,r,signal} = \Sigma (T_{cfa,r}(\lambda) * e_{num,wb,signal}(\lambda))$
$e_{det,r,haze} = \Sigma (T_{cfa,r}(\lambda) * e_{num,wb,haze}(\lambda))$

likewise, the total number of electrons for the green and blue pixels due to solar radiation is computed in a similar manner.

Total RMS number of electrons due to sensor and electronic noise[9,13]; $e_{s\&enoise}$ [electrons]

$e_{s\&enoise} = \sqrt{(e_{sensornoise})^2 + (e_{shotnoise})^2 + (e_{quannoise})^2}$ (R17)

where:

$e_{sensornoise}$ = sensor noise
$e_{shotnoise}$ = shot noise = $\sqrt{e_{det}}$
$e_{quannoise}$ = quantization noise = $e_{det} / (2^{\#bit} * \sqrt{12})$

where:

#bit = the number of bits (8 or 12)

Grand total number of electrons; e_{sum} [electrons]

$e_{sum} = e_{det} + e_{s\&enoise}$ (R18)

Camera Digital Counts:

8-bit counts for SIGNAL e's = ROUND ($e_{det, ,signal}$ / Γ) (R19)

8-bit counts for HAZE e's = ROUND ($e_{det,b,haze}$ / Γ) (R20)

8-bit counts for total (sig + haze) e's = ROUND ($e_{det,b}$ / Γ) (R21)

8-bit counts for total sensor and electronics noise e's
= ROUND ($e_{s\&enoise}$ / Γ) (R22)

8bit counts for grand total e's = ROUND (e_{sum} / Γ) (R23)

where:

Γ = quantization interval = (∂ / $2^{\#bit}$)
where: ∂ = detector saturation level in electrons

The 12-bit digital count equations are identical to the 8-bit equations, except the #bits = 12 instead of 8.

3.2.5 Image Quality Model Equations

Sub-section 3.2.5 outlines the equations for the image quality portion of the model. The main reference sources for these equations are: Ekiert[9], Schott[13], and Tantalo[15]. These equations analytically define all of the imaging chain component's contributions to the final image quality of the output image. By using a linear system approach (i.e. TMA), the model cascades all of the appropriate contributions to predict a final camera resolution.

Ground sample distance: GSD_{it}[9,13]; GSD_{ct}

$GSD_{it} = (P_{it} * A) / FL$ (IQ1A)

$GSD_{ct} = (P_{ct} * A) / FL$ (IQ1B)

where;

P_{it} = in-track pixel size

P_{ct} = cross-track pixel size

A = aircraft altitude above the ground

FL = focal length of the lens

Nyquist limited ground resolving distance[9,13]: GRD_{nyqt}

$GRD_{nyqt,it} = 2 * GSD_{it}$ (IQ2A)

$GRD_{nyqt,ct} = 2 * GSD_{ct}$ (IQ2B)

MTFs

ν denotes the frequency for the in-track spatial direction

η denotes the frequency for the cross-track spatial direction

Atmospheric MTF: $MTF_{atmos}(\nu)$; $MTF_{atmos}(\eta)$

$MTF_{atmos}(\nu) = MTF_{atmos}(\eta)$ = constant for all frequencies (IQ3)

Aircraft linear motion MTF: $MTF_{aircraft}(\nu)$[9,13]; $MTF_{aircraft}(\eta)$

$MTF_{aircraft}(\nu) = sinc(\nu * \forall_{eqamt} * P_{it})$ (IQ4A)

where:

$\forall_{eqamt}$ = equivalent pixel factor = Ω / P_{it}

Ω_{it} = in-track smear amount = aircraft $speed_{it}$ * integration time *(fl / ALT)

P_{it} = pixel size in the in-track direction

$MTF_{aircraft}(\eta) = sinc(\eta * \forall_{eqamt} * P_{ct})$ (IQ4B)

where:

$\forall_{eqamt}$ = equivalent pixel factor = Ω / P_{ct}

Ω_{ct} = cross-track smear amount = aircraft $speed_{ct}$ * integration time *(fl / ALT)
P_{ct} = Pixel size in the cross-track direction

The following three figures, show the effects of integration time, aircraft speed, and altittude on the $MTF_{aircraft}$.

AIRCRAFT MOTION MTF (LINEAR SMEAR)
FL= 28 MM; PIXEL = 9 MIC; ALT. = 3000 FT; SPEED = 100 MPH

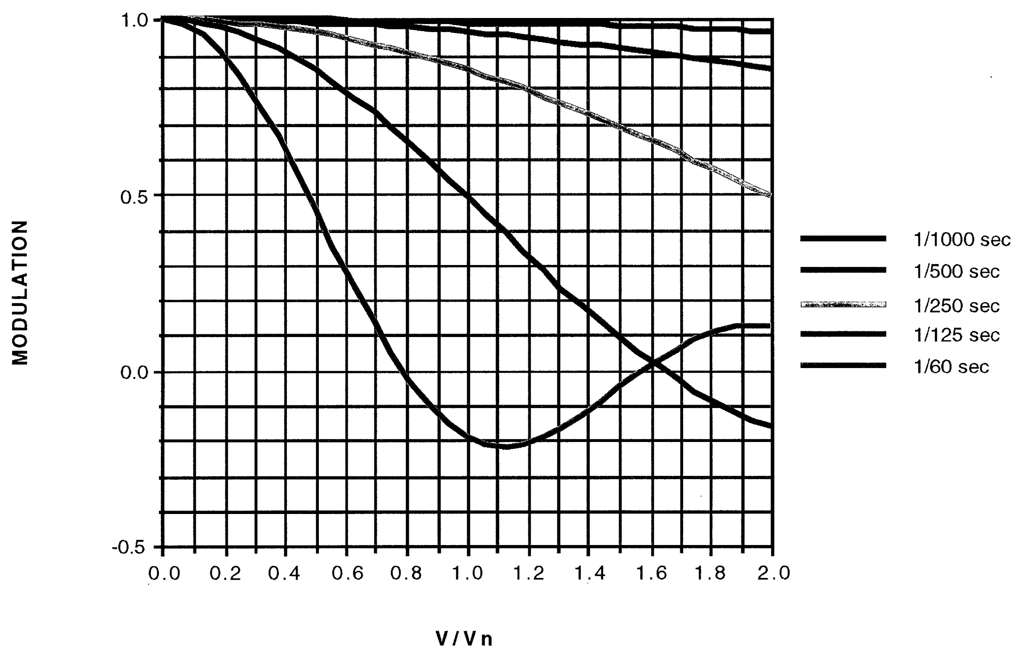


Figure 21: Aircraft Motion MTF for Various Integration Times Plot

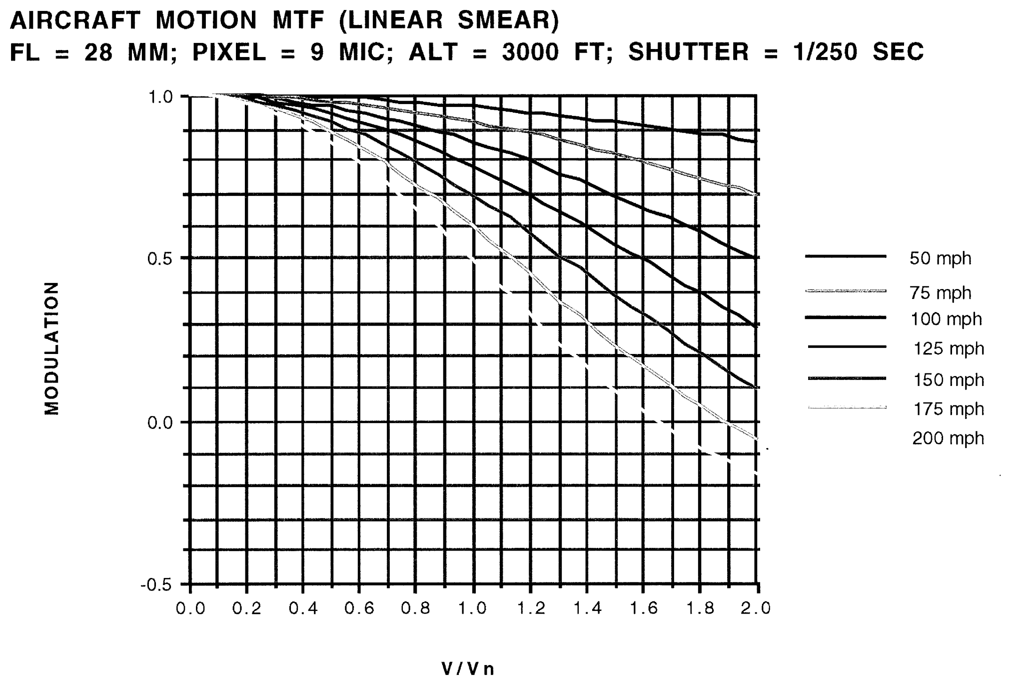


Figure 22: Aircraft Motion MTF for Various Aircraft Speeds Plot

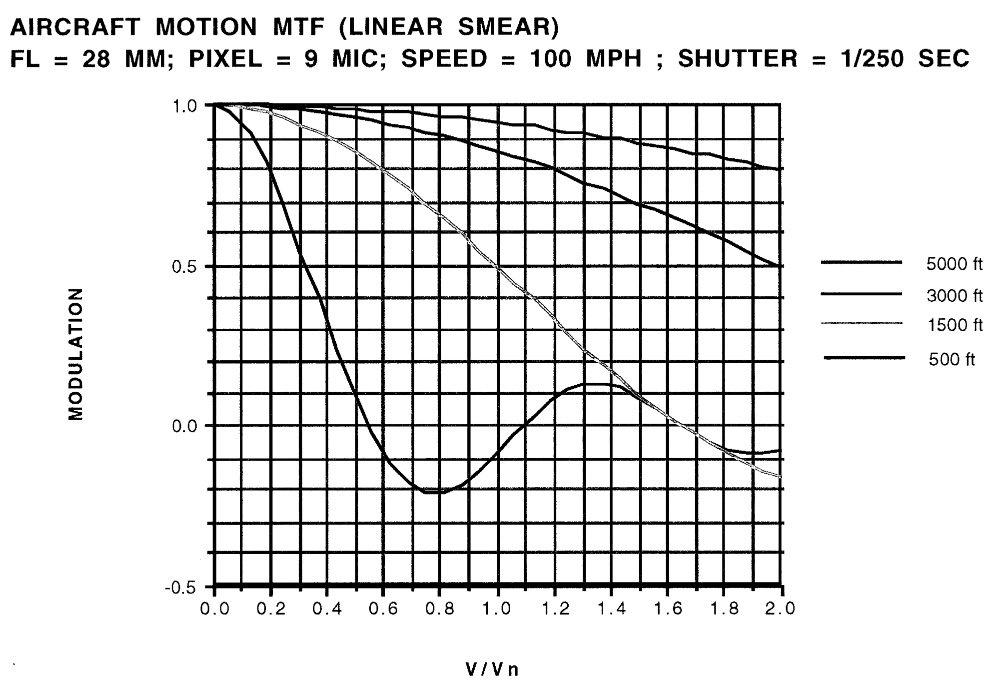


Figure 23: Aircraft Motion MTF for Various Aircraft Altitudes Plot

Optics MTF: Diffraction limited circular aperture lens MTF[14]: MTF(ν)$_{difflens}$

$$MTF(\nu)_{difflens} = (2/\pi)*(\phi - \cos(\phi) * \sin(\phi)) * \cos(\theta)^k = MTF(\eta)_{difflens} \quad \text{(IQ5)}$$

where:

$\phi = \cos^{-1}(\nu/\nu_o)$

$\nu_o = 1/(\lambda * F/\#)$

θ = is the half angle

k = 1 for radial lines and 3 for tangential lines

Detector MTF: MTF$_{det}$(ν)[9,13,15]; MTF$_{det}$(η)

$$MTF_{det}(\nu) = sinc(\nu * P_{it}) \quad \text{(IQ6A)}$$

where P_{it} = pixel size in the in-track direction

$$MTF_{det}(\eta) = sinc(\eta * P_{ct}) \quad \text{(IQ6B)}$$

where: P_{ct} = pixel size in the cross-track direction

Charge transfer MTF: MTF$_{chg}$(ν)[9]; MTF$_{chg}$(η)

$$MTF_{chg}(\nu) = EXP[-\gamma_{it}(1-\varepsilon)(1-\cos(\alpha_{it})] \quad \text{(IQ7A)}$$

where: γ_{it} = # of charge transfers in the in-track direction

ε = charge transfer efficiency

$\alpha_{it} = 2 * \pi * P_{it} * \nu$

$$MTF_{chg}(\eta) = EXP[-\gamma_{ct}(1-\varepsilon)(1-\cos(\alpha_{ct})] \quad \text{(IQ7B)}$$

where: γ_{ct} = # of charge transfers in the in-track direction

ε = charge transfer efficiency

$\alpha_{ct} = 2 * \pi * P_{ct} * \eta$

Detector clocking MTF: MTF$_{clock}$(ν)[9]; MTF$_{clock}$(η)

$$MTF_{clock}(\nu) = sinc(\nu * P_{it}/\Phi_{clock}) \quad \text{(IQ8A)}$$

$$MTF_{clock}(\eta) = sinc(\eta * P_{ct}/\Phi_{clock}) \quad \text{(IQ8B)}$$

where: Φ_{clock} = # of phase clocks

Interpolation MTF (weighted average MTF)[1]:

Green interpolation: $MTF_{interp,grn}(\nu)$; $MTF_{interp,grn}(\eta)$

$$MTF_{interp,grn}(\nu) = 0.75 + (0.25 * COS(2 * \pi * \nu/(2 * \nu_n))) \quad (IQ9A)$$

$$MTF_{interp,grn}(\eta) = 0.75 + (0.25 * COS(2 * \pi * \eta/(2 * \eta_n)) \quad (IQ9B)$$

where:

ν_n = Nyquist frequency = $1/(2 * P_{it})$

η_n = Nyquist frequency = $1/(2 * P_{ct})$

Red interpolation: $MTF_{interp,red}(\nu)$; $MTF_{interp,red}(\eta)$

$$MTF_{interp,red}(\nu) = MTF_{interp,grn}(\nu) + (0.5+(2 * (-0.1875) * COS(2 * \pi * \nu/(2 * \nu_n))) + (2 * (-0.0625) * COS(4 * \pi * \nu/(2 * \nu_n))) \quad (IQ10A)$$

$$MTF_{interp,red}(\eta) = MTF_{interp,grn}(\eta) + (0.5+(2 * (-0.1875) * COS(2 * \pi *\eta/(2 *\eta_n))) + (2 * (-0.0625) * COS(4 * \pi * \eta/(2 * \eta_n))) \quad (IQ10B)$$

Blue interpolation: $MTF_{interp,blue}(\nu)$; $MTF_{interp,blue}(\eta)$

$$MTF_{interp,blue}(\nu) = MTF_{interp,red}(\nu) \quad (IQ11A)$$

$$MTF_{interp,blue}(\eta) = MTF_{interp,red}(\eta) \quad (IQ11B)$$

Threshold Modulation Analysis[9]

Input modulation: ITM

$$ITM = MTF_{atmos} * MTF_{aircraft} * MTF_{optics} * MOD_{target} \quad \text{(IQ12)}$$

where:

MOD_{target} = target modulation = (C-1) / (C+1) (IQ13)
C = target to background contrast = $NDVI_{target} / NDVI_{background}$ (IQ14)

Required modulation: TM

$$TM = (\sqrt{(SNR_{req} * MOD_{noise})^2 + TM_{vis}}) / (MTF_{det} * MTF_{chg} * MTF_{clock} * MTF_{elec} * MTF_{interp}) \quad \text{(IQ15)}$$

where:

SNR_{req} = required minimum SNR for the eye

MOD_{noise} = noise modulation = $e_{s\&enoise} / e_{det,sig}$ (IQ16)

where:
$e_{s\&enoise}$ = total RMS number of electrons due to sensor & electronic noise
$e_{det,sig}$ = total number of electrons due to signal

TM_{vis} = required minimum modulation for the eye

4.0 Results

4.1 Flight Test Data

Figure 21 shows the results of flight test raw image going through two different Photoshop drivers. The flight test image (see Appendix 1) is the large Macbeth target @ ≅1300 feet AGL with the 28 mm lens. The X-axis is the average reflectance of the neutral gray patches. The CIR v3.0.1 with gamma = 1.0 driver and a linear driver. The CIR driver is a standard CIR driver that comes with the camera. The linear driver is a driver that can be obtained by special request. Note the linear driver does not backout the infrared signal from the red and green pixels channels.

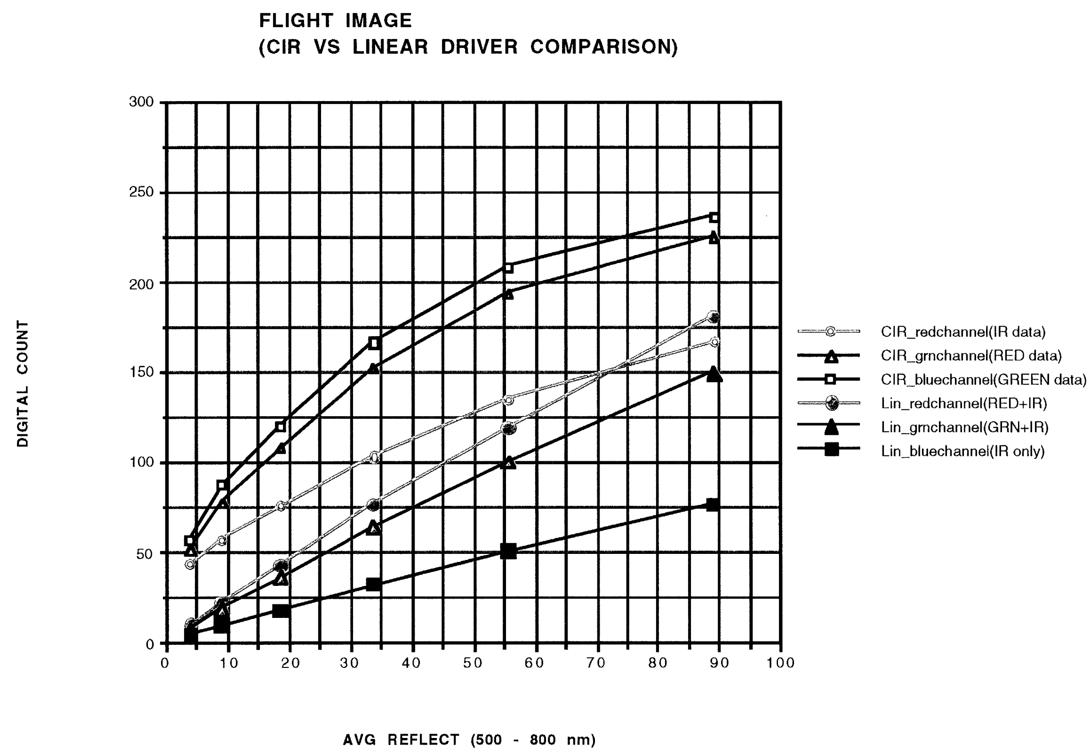


Figure 24: Driver Comparison Plot

4.2 Modeling Case Study - Three Wheat Curves

A modeling case study of wheat changes throughout the growing season was performed. The case study was used to show the utility of a CIR camera and the analytical model. The study compared the three temporal wheat curves shown previously in Figure 16. The study had the following input parameters:

Camera:	460 CIR
Filter:	650BP300
Lens:	28 mm
F/#:	F/5.6
Integration Time:	0.002, 0.004, 0.0067, 0.008, 0.01667 sec.
Altitude:	3000 feet
Aircraft Speed:	50, 100, 150, 200, 250, 300, 350 mph
Target:	Wheat data (Figure 16)
Atmosphere:	Roch-23, Roch-7, Roch-5+
Field of View:	On-axis; Half-Field, Full-Field
Solar Angle:	30 degree

The results of the study are shown in the following four tables. The first three tables are radiometric summaries while the fourth table is an image quality summary for the study. Table 1 summarizes the camera response differences from the different wheat inputs.

	******* WHEAT DIFFERENTIATION *******										
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-GRN	0.0	0.002	22	8	23	4	74	64	0.542	0.778
SUN ZEN ->	30	0.0	0.004	44	16	46	8	148	128	0.542	0.778
		0.0	**0.0067**	**73**	**27**	**77**	**13**	**246**	**213**	**0.542**	**0.775**
		0.0	0.008	88	32	92	16	296	256	0.542	0.778
		0.0	0.01667	183	66	191	34	615	533	0.541	0.780
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NEW	**0.0**	**0.0067**	**108**	**62**	**89**	**25**	**180**	**147**	**0.250**	**0.407**
SUN ZEN ->	30	0.0	0.008	130	74	106	31	216	177	0.249	0.410
		0.0	0.01667	271	154	221	64	450	369	0.248	0.411
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRE		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NORM	**0.0**	**0.0067**	**66**	**20**	**88**	**24**	**201**	**168**	**0.506**	**0.787**
SUN ZEN ->	30	0.0	0.008	79	24	105	29	241	202	0.506	0.788
		0.0	0.01667	165	49	219	61	503	421	0.506	0.791

Table 1: Wheat Differentiation

Table 2 below shows that the impact on NDVI due to lens fall-off is insignificant. While the lens fall-off does not impact the NDVI prediction, it will have a large impact on mosaicing images together. If the fall-off is not corrected for, the resultant mosaic will have dark sections butted to light sections.

	********* LENS FALL-OFF EFFECT ***********										
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-GRN	**0.0**	**0.0067**	**73**	**27**	**77**	**13**	**246**	**213**	**0.542**	**0.775**
SUN ZEN ->	30	0.5	0.00667	63	23	66	12	213	184	0.543	0.778
		1.0	0.00667	44	16	46	8	146	127	0.537	0.776
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NEW	**0.0**	**0.0067**	**108**	**62**	**89**	**25**	**180**	**147**	**0.250**	**0.407**
SUN ZEN ->	30	0.5	0.00667	94	53	77	22	156	127	0.248	0.411
		1.0	0.00667	65	37	53	15	107	88	0.244	0.408
CAMERA ->	460										
ATMOS ->	ROCH-23			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP	REL.		(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	FLD	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NORM	**0.0**	**0.0067**	**66**	**20**	**88**	**24**	**201**	**168**	**0.506**	**0.787**
SUN ZEN ->	30	0.5	0.00667	57	17	76	21	174	145	0.506	0.790
		1.0	0.00667	39	12	52	14	120	100	0.509	0.786

Table 2: Lens Fall-off Affect on NDVI Predictions

Table 3 shows the effects of different atmospheres on the imaging process. Atmospheres Roch-7 and Roch-5+ give some spurious results. This indicates that the two atmospheres are too water saturated for good imaging results.

	****** ATMOSPHERIC EFFECT ******										
CAMERA ->	460										
FLD PT ->	0.0			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP			(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	ATMOS	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-GRN	roch-23	0.01667	183	66	191	34	615	533	0.541	0.780
SUN ZEN ->	30	roch-7	0.01667	136	1	160	0	109	10	-0.110	0.810
		roch-5+	0.01667	265	2	320	0	252	66	-0.025	0.941
CAMERA ->	460										
FLD PT ->	0.0			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP			(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	ATMOS	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NEW	roch-23	0.01667	271	154	221	64	450	369	0.248	0.411
SUN ZEN ->	30	roch-7	0.01667	137	2	160	1	106	6	-0.128	0.5
		roch-5+	0.01667	276	13	323	3	231	44	-0.089	0.544
CAMERA ->	460										
FLD PT ->	0.0			MATRIX RED		MATRIX GRN		MATRIX BLUE		NDVI	
FILTER ->	650BP			(RED)		(GREEN)		(IR)			
F/# ->	F/5.6	ATMOS	expos.	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l	tot'l	sig'l
TARGET ->	WHEAT-NORM	roch-23	0.01667	165	49	219	61	503	421	0.506	0.791
SUN ZEN ->	30	roch-7	0.01667	135	1	160	1	107	8	-0.116	0.778
		roch-5+	0.01667	264	1	323	2	239	52	-0.05	0.962

Table 3: Atmospheric Impact on NDVI Predictions

Table 4 shows results of the image quality analysis. Note, the NDVI calculated in the radiometric analysis was used to compute the target contrast. The table clearly shows the WHEAT-GRN can easily be distinguished from the WHEAT-NEW. The WHEAT-GRN and the WHEAT-NORM are too similar to easily detect the difference. Note that for various aircraft speed, various components of the imaging change dominate the results. Also, note the presence of color aliasing as seen from the differences in GRD between the green and blue channels.

******FROM RADIOMETRIC	MODEL********************				
ALT=	3000FT		NDVI	CONTRAST	MOD
F/# =	F/5.6		(IR-RED)/(IR+RED)	NDVI1/NDVI2	(C-1)/(C+1)
FL=	28mm	**TARGET**			
PIXEL=	9MICRON	WHEAT-GRN	0.775	na	
ATMOS=	ROCH-23	WHEAT-NEW	0.407	1.904	0.311
SHUTTER =	1/150	WHEAT-NORM	0.787	1.015	0.008
TARGET e- =	48,100				
HAZE e- =	26,500				

GSD(in)=		11.57						
NYQUIST GRD(in)=		23.14						
			WHEAT-NEW TO WHEAT-GREEN COMPARISON					
			************** **PREDICTED GRD(in)****************					
AIRCRAFT SPEED->		**50.0**	**100.0**	**150.0**	**200.0**	**250.0**	**300.0**	**350.0**
PIXEL SMEAR->		0.51	1.010	1.52	2.03	2.53	3.04	3.55
LENS	**PIXEL**							
IFF LIMITED	GREEN	23.14	23.14	24.39	25.71	27.27	29.16	31.49
	BLUE	23.14	23.14	23.14	24.39	27.27	29.16	31.49
AVG. MEASURED LENS								
	GREEN	23.26	24.39	25.71	27.27	29.16	31.49	31.49
	BLUE	23.14	23.14	23.26	25.71	27.27	29.16	31.49

WHEAT-NORM TO WHEAT-GREEN COMPARISON

**************** **PREDICTED GRD(in)*******************

GRD = 257.14in
-> NOT ENOUGH CONTRAST TO DETECT A DIFFERENCE

Q: WHAT IS THE MINIMUM ALLOABLE TARGET CONTRAST WHICH CAN BE DETECTED?

ALT=	3000FT
F/#=	F/5.6
FL=	28mm
PIXEL=	9MICRON
ATMOS=	ROCH-23
SHUTTER=	1/150
SPEED=	100mph
LENS=	AVG. MEASURED

A: THE MINIMUM ALLOWABLE CONTRAST TO DETECT CHANGE IS 1.0661
->NDVI = 0.8262 (ASSUMING WHEAT-GRN AS THE REF)

PIXEL	GRD(in)
GREEN	257.14
BLUE	181.83

Table 4: Wheat Case-Study Image Quality Summary

5.0 Conclusion / Summary

The project has been very helpful on understanding the technical aspects of the CIR camera and its usefulness for remote sensing. The project's main focus of creating an analytical model of the CIR camera has been successfully accomplished. Clearly, the model can be useful to predict both radiometric and image quality camera performance in airborne applications. From the results presented, it is clear that the camera has excellent image capture capabilities for remote sensing applications. Because of the camera's unique filtering flexibility, one can only imagine the imaging possibilities. With the use of the model, one can easily predict and optimize performance before costly aerial flights occur. As presented throughout this paper, the measured data will be very useful for future analysis on other imaging research projects.

Suggestion for Future Follow-on Work

Lab and Field Radiometric Camera Calibration Testing

A better understanding of the actual camera output relative to the model's results needs to be explored. One approach, to baseline the camera's actual performance, involves the use of an integrating sphere and a calibrated blackbody light source. The light source could be easily filtered and therefore, camera output to known spectral radiance input data could be collect. The results of this valuable lab data could be incorporated into the model to incorporate the offsets and gain parameters in the color balance section of the model. Once the lab work was completed, a similar experiment could be performed outside using multiple cameras at multiple altitudes to better understand the atmospheric impacts on the camera performance.

Modeling the Current Driver V3.0.3 Interpolation

The model currently does not perform the color interpolation function that the camera software driver does. Currently, the color interpolation technique used in the driver is a Kodak proprietary algorithm. If the proprietary algorithm was incorporated into the model, it would enhance its accuracy and predictability. One could also compare the results of the data with results from using another interpolation to see if there is a better choice for interpolations when radiometric integrity of the data is essential.

Filter Study

The model could be used to design and optimize new band-pass filters based on unique detection applications. The current band-pass filter was designed for pest detection in forests. While this filter works well for other applications, it probably is not the optimal filter for every remote sensing application. Broader band passes and/or narrower band passes may yield better results for certain applications.

Measured Temporal Spectral Reflectance Data of Various Plants

Currently, the model only has wheat incorporated for temporal studies. One could easily incorporate other types of crop data into the model once the data is measured or is located. Note the model used spectral reflectance data from 400 nm to 1000 nm at 5 nm increments.

8-bit vs 12-bit vs 14-bit

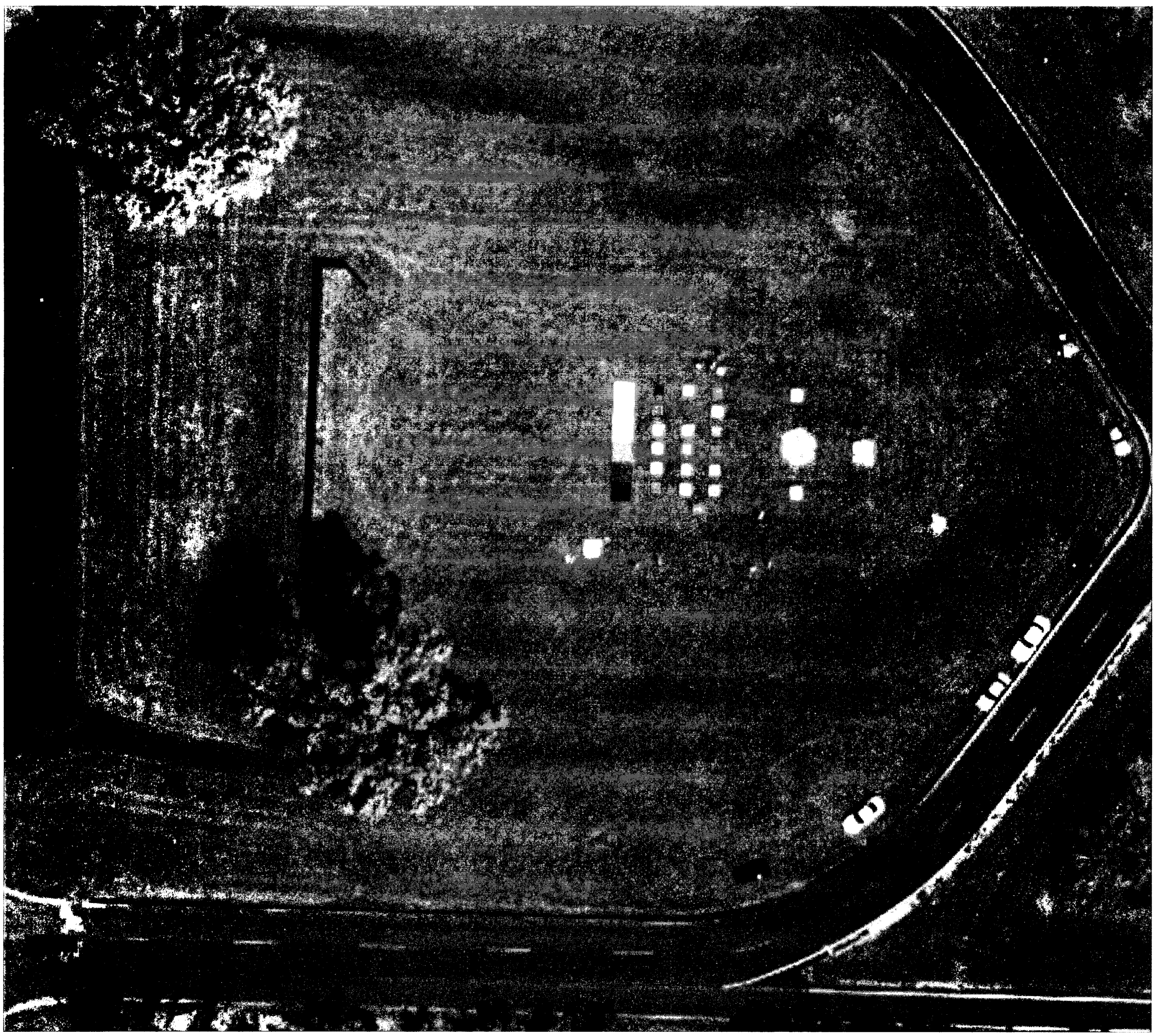
The model predicts both 8-bit and 12-bit radiometric results. One could perform a study to predict the enhanced detection capabilities of the camera if 12-bit or even 14-bit data was accessible to the end user. Currently, the CIR camera does not let the end user have access to the original 12-bit. If the results of a larger dynamic range study show significant improvements for remote sensing, there may be ways to incorporate this into the camera. The modifications needed to the camera must be compared to the cost of implementing these changes to see if it is financially beneficial.

Visual Simulations

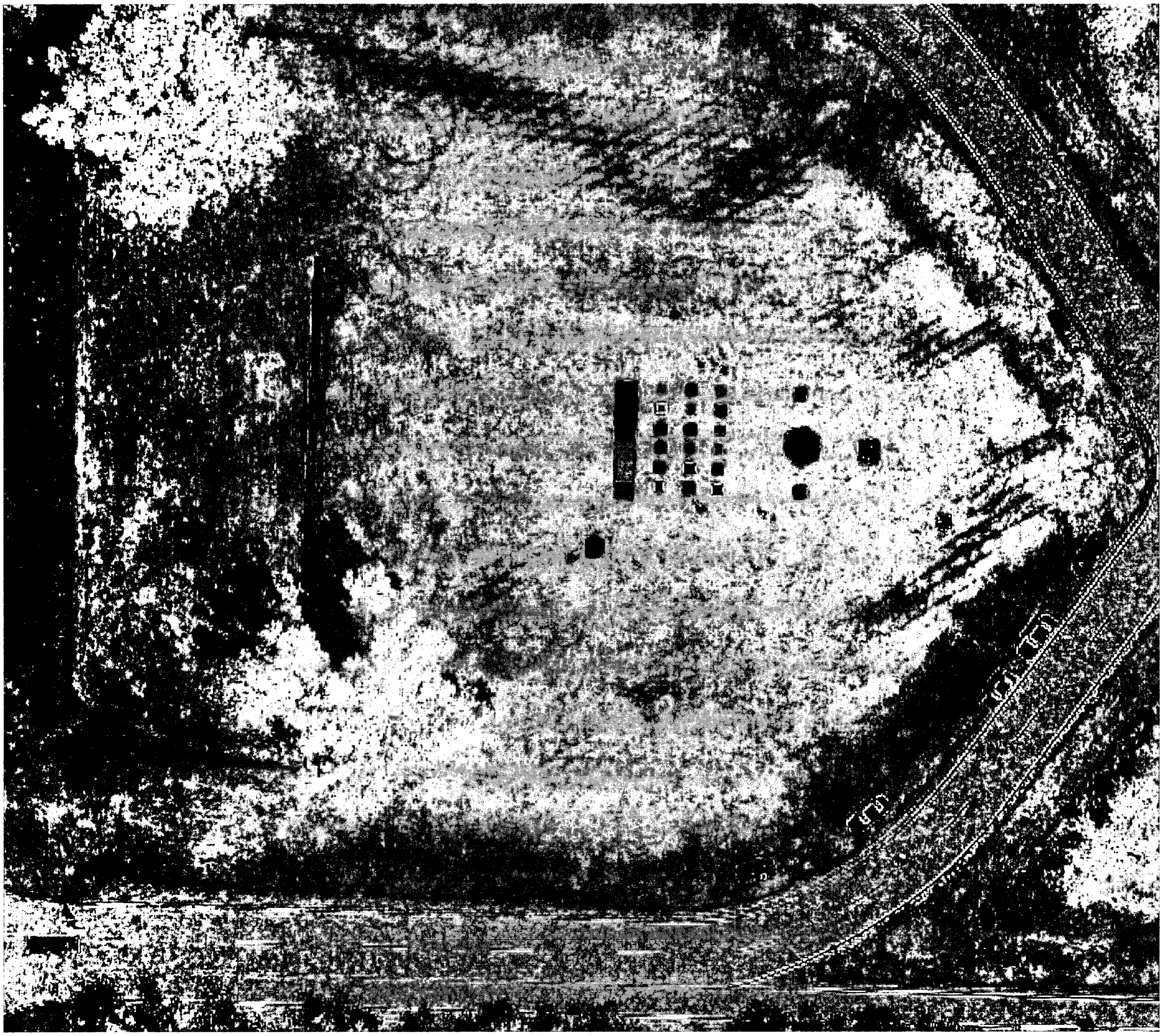
Incorporation of the CIR camera parameters into DIRSIG. This would help further validate the camera model. Also, once the camera parameters are in DIRSIG, visual simulations of the CIR camera 's output image can easily be generated. One interesting visual simulation that could be produced, is the color aliasing artifacts caused by under sampling a busy scene and the color interpolation processing[15].

6.0 Appendix

Appendix 1 - Flight Test Image



Appendix 2 - NDVI Image of the Flight Test Image



Appendix 3 - Radiometric Model Sample Run

CONSTANTS:

FOR BLACKBODY EMITTER

M = SPECTRAL RADIANT EXITANCE (q/sec*cm^2*um

E = SPECTRAL IRRADIANCE AT THE DETECTOR (q/sec*cm^2*um)

WL = EMITTED WAVELENGTH IN (UM)

T = BLACKBODY TEMP IN (DEG K)

h = PLANCK'S CONSTANT	6.63E-34	WSEC^2
c = SPEED OF LIGHT	3.00E+10	CM/SEC
k = BOLTZMAN'S CONSTANT	1.38E-23	WSEC/K
hc=	1.98648E-25	w-m-sec
Rs = SUN RADIUS	432000	MILES
Res = EARTH TO SUN DISTANCE	9.30E+07	MILES

INPUTS:

CAMERA TYPE(420 or 460):=	460
FIELD POINT(0.0,0.25,0.5,0.75,1.0):=	0
PIXEL SIZE (um) =	9.0
FILL FACTOR =	1
SATURATION LEVEL(e)=	85000
SENSOR NOISE (e-)=	20
FL(mm) =	28
F/# =	5.6
TI(sec) =	0.006666667
SUN ZENITH ANG(deg)=	30.00

Delta WL (um) =	0.005
ANGLE (RAD) =	0.09

	LENS FALL-OFF ENERGY FACTOR	
FIELD POINT	420	460
0.000	1.000	1.000
0.250	0.991	0.963
0.500	0.963	0.864
0.750	0.920	0.732
1.000	0.865	0.594

460.00   1.000

ERROR: 1

OPTIONS FOR EXOATMOS IRRAD	OPTIONS FOR T1	OPTIONS FOR TARGET REFLECT	OPTIONS FOR DOWNWELLED RAD	OPTIONS FOR T2	OPTIONS FOR UPWELLED RAD	OPTIONS FOR FILTER
		White				
		Neutral-5				
		Neutral-3.5				
		Black				
Es-roch23	*T1-roch23*	*WHEAT-GRN*	*SLd-roch23*	*T2-roch23*	*SLu-roch23*	*650BP*
Es-roch7	*T1-roch7*	*WHEAT-NEW*	*SLd-roch7*	*T2-roch7*	*SLu-roch7*	*VIS*
Es-roch5+	*T1-roch5+*	*WHEAT-NORM*	*SLd-roch5+*	*T2-roch5+*	*SLu-roch5+*	
enter data name	**enter data name**	**enter data name**	**enter data name**	**enter data name**	**enter data name**	**enter data name**
Es-roch23	*T1-roch23*	*WHEAT-GRN*	*SLd-roch23*	*T2-roch23*	*SLu-roch23*	*650BP*

WL(nm)	WL(um)	SIG TERM Exoatmos Irrad Es(Watts/m^2*um) Es Es-roch23 Es(Watts/m^2*um)	atmos trans SUN TO TARGET TRAN T1 T1-roch23 (%)	Target Reflectance R WHEAT-GRN reflect	SIG TERM Downwelled Radiance (Watts/m^2*um*sr) SLd SLd-roch23 (W/m^2-um-sr)	Atmos Trans TARGET TO SENSOR TRANS T2 T2-roch23 (%)	HAZE TERM Upwelled Radiance (Watts/m^2*um*sr) SLu SLu-roch23 (Watts/m^2*um*sr	SIGNAL Only Radiance at Front of Lens; L (Watts/m^2*um*sr)	TOTAL(SIG+HAZE) Radiance at Front of Lens; L (Watts/m^2*um*sr)	Filter Trans 650BPfilter trans	MEASURED data Nikon 28mm Lens Trans %	SIGNAL Only Radiance at Detector (Watts/m^2*um*sr)
400	0.4	1581.18675	17.72445	6.00000	0.00216	49.66134	35.99856	2.308	38.307	0.00000	68.999	0.00E+00
405	0.405	1688.69856	18.61439	6.00000	0.00251	50.63874	37.24891	2.640	39.889	0.00000	73.530	0.00E+00
410	0.41	1374.12569	19.50719	6.00000	0.00167	51.58924	28.67223	2.292	30.965	0.00000	77.014	0.00E+00
415	0.415	1840.53909	20.38565	6.00000	0.00000	52.50366	37.73976	3.258	40.998	0.00000	79.418	0.00E+00
420	0.42	1456.85491	21.25164	6.00000	0.00000	53.38406	28.79698	2.734	31.531	0.00000	81.262	0.00E+00
425	0.425	1533.49884	22.11124	6.10000	0.00001	54.23776	28.95379	3.093	32.046	0.00000	82.669	0.00E+00
430	0.43	1162.74070	22.97714	6.10000	0.00346	55.06979	21.30790	2.486	23.794	0.00000	83.780	0.00E+00
435	0.435	1775.58665	23.78755	6.10000	0.00434	55.86130	31.54837	3.982	35.531	0.00000	84.666	0.00E+00
440	0.44	1673.48008	24.64067	6.00000	0.00275	56.64059	28.82105	3.872	32.693	0.00000	85.417	0.00E+00
445	0.445	1928.96352	25.45499	6.00000	0.00148	57.39069	32.26722	4.666	36.933	0.00000	86.086	0.00E+00
450	0.45	2029.53830	26.31799	6.00000	0.00001	58.13504	33.18369	5.136	38.320	0.00000	86.674	0.00E+00
455	0.455	1912.72543	27.12490	6.00000	0.00094	58.84287	30.28482	5.053	35.338	0.00000	87.220	0.00E+00
460	0.46	1989.51150	27.92268	5.90000	0.00433	59.52916	30.33887	5.394	35.733	0.00000	87.772	0.00E+00
465	0.465	1840.58963	28.70857	5.90000	0.00558	60.19763	27.23888	5.193	32.432	0.00000	88.245	0.00E+00
470	0.47	1892.17001	29.51634	5.90000	0.00577	60.85826	27.16033	5.549	32.709	0.00000	88.689	0.00E+00
475	0.475	2003.22894	30.26349	5.80000	0.00558	61.48496	28.05407	5.980	34.034	0.00000	89.064	0.00E+00
480	0.48	2022.47236	31.03440	5.80000	0.00356	62.10165	27.42924	6.245	33.674	0.00000	89.398	0.00E+00
485	0.485	1857.70562	31.81494	5.80000	0.00084	62.71219	24.57103	5.929	30.500	0.00000	89.675	0.00E+00
490	0.49	2032.38687	32.54966	5.90000	0.00003	63.29490	25.98790	6.810	32.798	0.00000	89.920	0.00E+00
495	0.495	2032.34506	33.30139	5.90000	0.00133	63.86636	25.30229	7.035	32.337	0.00527	90.103	2.64E-06
500	0.5	1843.90780	34.01442	6.00000	0.00141	64.43525	22.31888	6.690	29.009	0.00000	90.286	0.00E+00
505	0.505	1823.25857	34.72745	6.10000	0.00429	64.96917	21.44779	6.934	28.382	24.83661	90.440	1.23E-02
510	0.51	1872.26130	35.45753	6.30000	0.00736	65.50705	21.33686	7.583	28.920	36.50465	90.561	1.98E-02
515	0.515	1764.44867	36.19233	6.40000	0.00748	66.03592	19.71809	7.472	27.190	35.42209	90.610	1.90E-02
520	0.52	1797.24382	36.89361	6.60000	0.00706	66.55039	19.63655	8.060	27.696	31.16543	90.693	1.80E-02
525	0.525	1879.26641	37.58319	6.70000	0.00572	67.04890	19.84476	8.772	28.617	67.83156	90.731	4.27E-02
530	0.53	1836.85529	38.28278	6.90000	0.00499	67.54423	18.86692	9.058	27.925	37.44376	90.742	2.43E-02
535	0.535	1809.66822	38.97609	7.00000	0.00404	68.02904	18.23642	9.278	27.515	38.47294	90.843	2.56E-02
540	0.54	1718.01422	39.65670	7.00000	0.00616	68.50573	16.73435	9.036	25.770	66.54243	90.834	4.32E-02
545	0.545	1888.62697	40.31451	7.00000	0.00666	68.96860	18.07830	10.165	28.243	84.97219	90.827	6.20E-02
550	0.55	1824.69303	40.98805	7.00000	0.00797	69.42624	16.99080	10.058	27.049	83.59904	90.957	6.05E-02
555	0.555	1847.15014	41.54434	6.90000	0.00786	69.79983	16.71849	10.226	26.945	85.18217	90.986	6.27E-02
560	0.56	1779.23709	42.08217	6.70000	0.00765	70.16065	15.75167	9.738	25.490	83.08010	91.065	5.83E-02
565	0.565	1838.72452	42.59375	6.50000	0.00800	70.50934	15.91264	9.931	25.844	77.25565	91.170	5.53E-02
570	0.57	1788.14061	42.97071	6.20000	0.00707	70.76342	15.04993	9.324	24.374	73.05367	91.244	4.92E-02
575	0.575	1787.42085	43.54940	6.00000	0.00495	71.13966	14.69859	9.180	23.879	72.26422	91.404	4.80E-02
580	0.58	1789.43247	44.14199	5.70000	0.00258	71.52681	14.44625	8.888	23.334	74.53737	91.563	4.80E-02
585	0.585	1782.34879	44.61386	5.50000	0.00167	71.83673	14.05426	8.667	22.722	77.86558	91.701	4.89E-02
590	0.59	1668.96214	44.21366	5.30000	0.00625	71.60508	12.75420	7.743	20.498	79.32100	91.834	4.46E-02
595	0.595	1728.58862	44.81757	5.10000	0.00581	71.99051	12.85143	7.862	20.714	78.82555	92.058	4.51E-02

PIXEL OUPUT:			MONOCHROME	RAW RED	matrixed red	RAW GREEN	matrixed green	RAW BLUE	matrixed blue	NDVI		
				(red+ir)	(red)	(green+ir)	(green)	(ir)	(ir)	(ir-red)/(ir+red)		
		SIGNAL # of e's per pixel=	48128.14	31225.44	8804.53	18338.99	4450.38	13670.57	70803.58	0.779		
		HAZE # of e's per pixel=	26522.93	10672.62	15332.85	7124.86	20851.43	2061.09	10674.92	-0.179		
		Total(SIG+HAZE) # of e's per pixel=	74651.07	41898.07	24137.38	25463.85	25301.81	15731.66	81478.50	0.543		
		SENSOR NOISE(e-)=	20.00	20.00	20.00	20.00	20.00	20.00	20.00	0.000		
		SHOT NOISE(e-)=	273.22	204.69	155.36	159.57	159.07	125.43	285.44	0.295		
		12bit QUANTIZE NOISE(e-)=	5.26	2.95	1.70	1.79	1.78	1.11	5.74	0.543		
		8bit QUANTIZE NOISE(e-)=	84.18	47.25	27.22	28.71	28.53	17.74	91.88	0.543		
		Total Sensor&Elec Noise # of e's per pixel=	286.64	211.04	159.00	163.38	162.85	128.25	300.59	0.308		
		Grand Total # of e's per pixel=	74937.71	42109.11	24296.38	25627.22	25464.66	15859.91	81779.09	0.542		
	12bit constant=	20.75										
	8bit constant=	16.00										
		12bit counts for SIGNAL e's=	2319	1505	424	884	214	659	3412	0.779		
		12bit counts for HAZE e's=	1278	514	739	343	1005	99	514	-0.180		
		12bit counts for total(sig+haze) e's=	3597	2019	1163	1227	1219	758	3926	0.543		
		12bit counts for TotalSensor &ElectronicsNoise e's=	14	10	8	8	8	6	14	0.273		
		12bit counts for grand total e's=	3611	2029	1171	1235	1227	764	3941	0.542		
		8bit counts for SIGNAL e's=	145	94	27	55	13	41	213	0.775	normalization factor->	80.00
		8bit counts for HAZE e's=	80	32	46	21	63	6	32	-0.179		
		8bit counts for total(sig+haze) e's=	225	126	73	77	76	47	245	0.541		
		8bit counts for TotalSensor &ElectronicsNoise e's=	1	1	1	1	1	0	1	0.000		normalized
		8bit counts for grand total e's=	226	127	73	77	77	48	246	0.542		FILT
												CFA
TOTAL(SIG+HAZE)	SIGNAL Only	TOTAL(SIG+HAZE)	Q.E. Norm Factor=	0.45	MONOCHROME	MONOCHROME	MONOCHROME	MONOCHROME			Y91	RED
Radiance at	IRRADIANCE at	IRRADIANCE at			SIGNAL Only	SIGNAL Only	TOTAL(SIG+HAZE)	TOTAL(SIG+HAZE)			CFA-2	13-15
Detector	Detector	Detector	M6 NORM Q.E.		# of electrons	# of electrons	# of electrons	# of electrons			WAVE	CF2-B
(Watts/m^2*um*sr)	(q/sec-m^2-µm)	(q/sec-m^2-µm)		M6 Q.E	# of e- at wl	e- per deltawl	# of e- at wl	e- per deltawl				
0.00E+00	0.00E+00	0.00E+00	0.175	0.07875	0	0	0	0			400	0.1517
0.00E+00	0.00E+00	0.00E+00	0.18	0.081	0	0	0	0			405	0.13245
0.00E+00	0.00E+00	0.00E+00	0.185	0.08325	0	0	0	0			410	0.1132
0.00E+00	0.00E+00	0.00E+00	0.155	0.06975	0	0	0	0			415	0.1022
0.00E+00	0.00E+00	0.00E+00	0.125	0.05625	0	0	0	0			420	0.0912
0.00E+00	0.00E+00	0.00E+00	0.1325	0.059625	0	0	0	0			425	0.0865
0.00E+00	0.00E+00	0.00E+00	0.14	0.063	0	0	0	0			430	0.0818
0.00E+00	0.00E+00	0.00E+00	0.175	0.07875	0	0	0	0			435	0.07875
0.00E+00	0.00E+00	0.00E+00	0.21	0.0945	0	0	0	0			440	0.0757
0.00E+00	0.00E+00	0.00E+00	0.245	0.11025	0	0	0	0			445	0.07375
0.00E+00	0.00E+00	0.00E+00	0.28	0.126	0	0	0	0			450	0.0718
0.00E+00	0.00E+00	0.00E+00	0.3	0.135	0	0	0	0			455	0.0726
0.00E+00	0.00E+00	0.00E+00	0.32	0.144	0	0	0	0			460	0.0734
0.00E+00	0.00E+00	0.00E+00	0.31	0.1395	0	0	0	0			465	0.0777
0.00E+00	0.00E+00	0.00E+00	0.3	0.135	0	0	0	0			470	0.082
0.00E+00	0.00E+00	0.00E+00	0.295	0.13275	0	0	0	0			475	0.08985
0.00E+00	0.00E+00	0.00E+00	0.29	0.1305	0	0	0	0			480	0.0977
0.00E+00	0.00E+00	0.00E+00	0.285	0.12825	0	0	0	0			485	0.10815
0.00E+00	0.00E+00	0.00E+00	0.28	0.126	0	0	0	0			490	0.1186
1.21E-05	2.07E+13	9.51E+13	0.28	0.126	1	0	6	0			495	0.1252
0.00E+00	0.00E+00	0.00E+00	0.28	0.126	0	0	0	0			500	0.1318
5.04E-02	9.84E+16	4.03E+17	0.305	0.13725	7292	36	29845	149			505	0.1245
7.56E-02	1.60E+17	6.10E+17	0.33	0.1485	12823	64	48905	245			510	0.1172
6.90E-02	1.54E+17	5.62E+17	0.38	0.171	14264	71	51908	260			515	0.10255
6.19E-02	1.48E+17	5.09E+17	0.43	0.1935	15482	77	53202	266			520	0.0879
1.39E-01	3.55E+17	1.16E+18	0.48	0.216	41350	207	134895	674			525	0.0782
7.50E-02	2.04E+17	6.29E+17	0.53	0.2385	26275	131	81005	405			530	0.0685
7.61E-02	2.17E+17	6.43E+17	0.585	0.26325	30847	154	91476	457			535	0.0682
1.23E-01	3.69E+17	1.05E+18	0.64	0.288	57369	287	163616	818			540	0.0679
1.72E-01	5.35E+17	1.49E+18	0.69	0.3105	89668	448	249140	1246			545	0.07095
1.63E-01	5.26E+17	1.41E+18	0.74	0.333	94611	473	254432	1272			550	0.074
1.65E-01	5.50E+17	1.45E+18	0.795	0.35775	106287	531	280054	1400			555	0.07205
1.53E-01	5.16E+17	1.35E+18	0.85	0.3825	106593	533	279006	1395			560	0.0701
1.44E-01	4.94E+17	1.29E+18	0.885	0.39825	106310	532	276645	1383			565	0.0665
1.28E-01	4.43E+17	1.16E+18	0.92	0.414	99060	495	258953	1295			570	0.0629
1.25E-01	4.36E+17	1.13E+18	0.925	0.41625	98026	490	254976	1275			575	0.0687
1.26E-01	4.40E+17	1.16E+18	0.93	0.4185	99448	497	261088	1305			580	0.0745
1.28E-01	4.53E+17	1.19E+18	0.925	0.41625	101786	509	266836	1334			585	0.10705
1.18E-01	4.16E+17	1.10E+18	0.92	0.414	93059	465	246335	1232			590	0.1396
1.19E-01	4.25E+17	1.12E+18	0.925	0.41625	95439	477	251440	1257			595	0.2208

80.00	80.00												
normalized	normalized												
FILT	FILT												
CFA	CFA												
GREEN	BLUE	RED Pixel	**RED Pixel**	RED Pixel	**RED Pixel**	GREEN Pixel	**GREEN Pixel**	GREEN Pixel	**GREEN Pixel**	BLUE Pixel	**BLUE Pixel**	BLUE Pixel	**BLUE Pixel**
31966	31872	SIGNAL Only	**SIGNAL Only**	TOTAL(SIG+HAZE)	**TOTAL(SIG+HAZE)**	SIGNAL Only	**SIGNAL Only**	TOTAL(SIG+H/	**TOTAL(SIG+HAZE)**	SIGNAL Only	**SIGNAL Only**	TOTAL(SIG+HA	**TOTAL(SIG+H**
CF2-C	CF2-D	# of electrons	**# of electrons**	# of electrons	**# of electrons**	# of electrons	**# of electrons**	# of electrons	**# of electrons**	# of electrons	**# of electron**	# of electrons	**# of electron**
		# of e- at wl	**e- per deltawl**	# of e- at wl	**e- per deltawl**	# of e- at wl	**e- per deltawl**	# of e- at wl	**e- per deltawl**	# of e- at wl	**e- per deltawl**	# of e- at wl	**e- per deltaw**
0.1042	0.4335	0	0	0	0	0	0	0	0	0	0	0	0
0.09975	0.4909	0	0	0	0	0	0	0	0	0	0	0	0
0.0953	0.5483	0	0	0	0	0	0	0	0	0	0	0	0
0.0901	0.5796	0	0	0	0	0	0	0	0	0	0	0	0
0.0849	0.6109	0	0	0	0	0	0	0	0	0	0	0	0
0.0833	0.629	0	0	0	0	0	0	0	0	0	0	0	0
0.0817	0.6471	0	0	0	0	0	0	0	0	0	0	0	0
0.08075	0.66005	0	0	0	0	0	0	0	0	0	0	0	0
0.0798	0.673	0	0	0	0	0	0	0	0	0	0	0	0
0.0796	0.67375	0	0	0	0	0	0	0	0	0	0	0	0
0.0794	0.6745	0	0	0	0	0	0	0	0	0	0	0	0
0.08355	0.6608	0	0	0	0	0	0	0	0	0	0	0	0
0.0877	0.6471	0	0	0	0	0	0	0	0	0	0	0	0
0.09955	0.6106	0	0	0	0	0	0	0	0	0	0	0	0
0.1114	0.5741	0	0	0	0	0	0	0	0	0	0	0	0
0.1364	0.51875	0	0	0	0	0	0	0	0	0	0	0	0
0.1614	0.4634	0	0	0	0	0	0	0	0	0	0	0	0
0.2131	0.3984	0	0	0	0	0	0	0	0	0	0	0	0
0.2648	0.3334	0	0	0	0	0	0	0	0	0	0	0	0
0.34965	0.27535	0	0	1	0	0	0	2	0	0	0	1	0
0.4345	0.2173	0	0	0	0	0	0	0	0	0	0	0	0
0.5206	0.1753	726	4	2973	15	3037	15	12430	62	1023	5	4186	21
0.6067	0.1333	1202	6	4585	23	6224	31	23737	119	1367	7	5215	26
0.6606	0.1068	1170	6	4259	21	7538	38	27432	137	1219	6	4435	22
0.7145	0.0803	1089	5	3741	19	8849	44	30410	152	995	5	3418	17
0.7279	0.06605	2587	13	8439	42	24079	120	78552	393	2185	11	7128	36
0.7413	0.0518	1440	7	4439	22	15582	78	48039	240	1089	5	3357	17
0.73285	0.04735	1683	8	4991	25	18085	90	53631	268	1168	6	3465	17
0.7244	0.0429	3116	16	8888	44	33247	166	94819	474	1969	10	5615	28
0.6987	0.0411	5090	25	14141	71	50121	251	139260	696	2948	15	8192	41
0.673	0.0393	5601	28	15062	75	50939	255	136986	685	2975	15	7999	40
0.6289	0.0343	6126	31	16142	81	53475	267	140901	705	2917	15	7685	38
0.5848	0.0293	5978	30	15647	78	49869	249	130530	653	2499	12	6540	33
0.53955	0.02465	5656	28	14718	74	45887	229	119411	597	2096	10	5455	27
0.4943	0.02	4985	25	13031	65	39172	196	102400	512	1585	8	4143	21
0.4546	0.0198	5388	27	14014	70	35650	178	92730	464	1553	8	4039	20
0.4149	0.0196	5927	30	15561	78	33009	165	86660	433	1559	8	4094	20
0.3734	0.02625	8717	44	22852	114	30406	152	79709	399	2138	11	5604	28
0.3319	0.0329	10393	52	27511	138	24709	124	65407	327	2449	12	6484	32
0.2751	0.04255	16858	84	44414	222	21004	105	55337	277	3249	16	8559	43

matrix#1

1	0	-1
0	1	-1
0	0	1

matrix#2

2.348	0	-2.492
0	2.89	-3.107
0	0	2.735

newman with haze

1.926	-0.508	-1.435
0.487	2.154	-3.062
-0.132	-0.651	3.61

newman no haze

1.523	-0.06	-1.093
-0.108	2.775	-2.345
-0.285	-0.338	3.539

R'	2.348	0	-2.492	R(RED+IR)
G'=	0	2.89	-3.107	G(GRN+IR)
B'	0	0	2.735	B(IR)

	RED	GREEN	BLUE
white point			
balance			
factor->	1	1.6016	1.8937

						red+ir	grn+ir	ir	red	grn	B
RED Pixel	GREEN Pixel	BLUE Pixel	r'	g'	b'	RED Pixel	GREEN Pixel	BLUE Pixel	RED MATRIXED	GRN MATRIXED	BLUE MATRIXED
SIGNAL Only	SIGNAL Only	SIGNAL Only	sig only	sig only	sig only	TOTAL(SIG+HA	TOTAL(SIG+HA	TOTAL(SIG+HAZE)	TOTAL(SIG+HA	TOTAL(SIG+HA	TOTAL(SIG+HAZE)
# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons	# of electrons
e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl	e- per deltawl
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.00070463	0.00315171	0.00293464	-0.00565864	-9.4863E-06	0.00802623	0.00323887	0.01448694	0.01348917	-0.02601016	-4.3604E-05	0.03689289
0	0	0	0	0	0	0	0	0	0	0	0
3.6313409	24.3195701	9.68257268	-15.6025827	40.1998044	26.4818363	14.8630363	99.5397189	39.6306579	-63.8611902	164.537334	108.389849
6.01142542	49.8399854	12.9476568	-18.1507339	103.809188	35.4118414	22.9267949	190.083224	49.3806796	-69.2245391	395.914745	135.056159
5.85103789	60.3656492	11.5393057	-15.0177128	138.604103	31.560001	21.2925398	219.67692	41.992742	-54.6510298	504.394851	114.850149
5.44335175	70.8653307	9.41681957	-10.6857244	175.542747	25.7550015	18.7057792	243.524815	32.360383	-36.7209048	603.243005	88.5056474
12.9343472	192.825089	20.688155	-21.1850351	492.986409	56.5821039	42.1952734	629.046618	67.4902525	-69.1112074	1608.25251	184.585841
7.19929677	124.780742	10.3095674	-8.78749324	328.58452	28.1966669	22.195394	384.698371	31.7843421	-27.0917953	1013.02434	86.9301755
8.41506949	144.824649	11.0638045	-7.81241774	384.167995	30.2595054	24.9547331	429.47482	32.8095079	-23.1675805	1139.24309	89.7340042
15.5814759	266.238784	18.6426347	-9.87214023	711.507418	50.9876059	44.4381394	759.309082	53.1685191	-28.1551983	2029.20866	145.4159
25.4479033	401.369539	27.9159625	-9.81490173	1073.22307	76.3501575	70.7060561	1115.19039	77.5634673	-27.2703407	2981.91053	212.136083
28.0049808	407.917826	28.1648401	-4.43108647	1091.37436	77.0308376	75.3119443	1096.98645	75.7418432	-11.916228	2934.96094	207.153941
30.6318643	428.228039	27.6149807	3.10708556	1151.77929	75.5269722	80.7115851	1128.33367	72.7624293	8.18682788	3034.81143	199.005244
29.8887277	399.347375	23.6574652	11.2243293	1080.61017	64.7031673	78.2331993	1045.28447	61.9229834	29.3794772	2828.4774	169.35936
28.278345	367.466795	19.8499971	16.9313615	1000.3051	54.289742	73.5876698	956.244968	51.654898	44.0598428	2603.05619	141.276146
24.9235236	313.692016	15.0072103	21.1224651	859.942524	41.0447203	65.1526323	820.022921	39.2303783	55.2162779	2247.97746	107.295085
26.9375052	285.485546	14.7020198	26.6118288	779.374054	40.2100242	70.0675322	742.580561	38.2416352	69.2204107	2027.24106	104.590872
29.6356409	264.335533	14.7647229	32.7907953	718.055696	40.3815172	77.804264	693.976271	38.7627318	86.0876842	1885.15562	106.016072
43.584828	243.487706	20.2390047	51.9015764	640.796883	55.3536779	114.259018	638.310797	53.0571972	136.06164	1679.86949	145.111434
51.9639916	197.869291	23.1912503	64.2188566	499.787037	63.4280695	137.553455	523.778173	61.3893678	169.993207	1322.98215	167.899921
84.2914287	168.201164	30.7606204	121.260809	390.528116	84.1302967	222.072011	443.138421	81.0411321	319.47058	1028.87524	221.647496

600	0.6	1727.67411	45.96221	5.00000	0.00488	72.70737	12.72146	7.976	20.697	79.27594	92.279	4.61E-02
605	0.605	1737.48111	46.63173	5.00000	0.00711	73.12085	12.56669	8.192	20.758	81.99553	92.447	4.91E-02
610	0.61	1676.86626	47.11244	5.00000	0.00791	73.42941	11.85093	8.025	19.876	84.73325	92.583	4.98E-02
615	0.615	1657.64146	47.58567	5.10000	0.00826	73.72805	11.50038	8.207	19.708	84.32906	92.838	5.08E-02
620	0.62	1657.02525	48.04917	5.20000	0.00832	74.01807	11.23760	8.480	19.717	81.41446	93.039	5.08E-02
625	0.625	1610.13936	48.50966	5.40000	0.00857	74.30441	10.67453	8.674	19.348	79.58307	93.135	5.08E-02
630	0.63	1627.51147	48.88710	5.50000	0.00837	74.53965	10.55615	9.026	19.582	80.31878	93.281	5.35E-02
635	0.635	1619.34040	49.36774	5.70000	0.00712	74.83528	10.31617	9.431	19.747	82.23457	93.419	5.73E-02
640	0.64	1540.42875	49.86035	5.80000	0.00713	75.13190	9.61852	9.257	18.876	82.80990	93.521	5.67E-02
645	0.645	1552.69114	50.13640	5.90000	0.00727	75.31066	9.46997	9.567	19.037	80.83708	93.635	5.73E-02
650	0.65	1505.22760	50.14350	6.00000	0.00845	75.33163	8.94616	9.442	18.389	78.25389	93.737	5.48E-02
655	0.655	1538.27113	50.73771	6.00000	0.00810	75.68482	8.97325	9.807	18.780	77.47378	93.732	5.63E-02
660	0.66	1487.50512	51.54191	6.00000	0.00813	76.15649	8.58529	9.695	18.280	78.50149	93.710	5.64E-02
665	0.665	1494.61483	52.08133	6.10000	0.00814	76.47636	8.47928	10.048	18.528	79.77304	93.636	5.94E-02
670	0.67	1492.43731	52.53093	6.20000	0.00853	76.74432	8.26409	10.324	18.588	79.12924	93.498	6.04E-02
675	0.675	1470.40829	52.97034	6.50000	0.00866	77.00448	7.98849	10.790	18.779	76.07555	93.388	6.06E-02
680	0.68	1448.86341	53.38776	6.90000	0.00828	77.25091	7.74169	11.410	19.152	71.66328	93.253	6.03E-02
685	0.685	1434.18168	53.78943	7.50000	0.00824	77.48831	7.47991	12.407	19.887	67.68081	93.065	6.18E-02
690	0.69	1423.97231	54.08486	8.40000	0.00844	77.66686	7.30888	13.906	21.215	64.40806	92.713	6.57E-02
695	0.695	1391.13565	52.57141	9.50000	0.00827	76.83770	6.79007	14.777	21.567	61.85298	92.484	6.69E-02
700	0.7	1365.21055	53.28117	11.00000	0.00749	77.24678	6.59138	17.102	23.693	59.41827	92.098	7.40E-02
705	0.705	1376.09130	54.26398	13.00000	0.00651	77.79667	6.61892	20.884	27.503	57.16548	91.724	8.66E-02
710	0.71	1358.76089	54.99325	15.00000	0.00580	78.20767	6.48635	24.232	30.719	55.05619	91.236	9.63E-02
715	0.715	1310.48383	54.13693	17.00000	0.00492	77.75005	6.02431	25.915	31.939	53.86133	90.792	1.00E-01
720	0.72	1298.13184	46.70187	20.00000	0.00829	73.47956	5.16938	24.682	29.851	54.25887	90.265	9.56E-02
725	0.725	1308.82306	48.34145	23.00000	0.00858	74.46465	5.26953	30.019	35.288	56.86705	89.694	1.21E-01
730	0.73	1289.07834	51.22789	25.00000	0.00794	76.12754	5.32894	34.797	40.126	61.03525	89.169	1.50E-01
735	0.735	1282.70455	55.28528	28.00000	0.00765	78.40563	5.55283	43.084	48.637	64.26401	88.489	1.94E-01
740	0.74	1247.16848	56.64651	30.00000	0.00757	79.14986	5.42327	46.423	51.846	63.85841	87.877	2.06E-01
745	0.745	1230.48352	57.42871	32.00000	0.00708	79.57833	5.31468	49.786	55.101	60.24275	87.175	2.07E-01
750	0.75	1210.57587	57.76401	34.00000	0.00805	79.76458	5.17295	52.496	57.669	57.41861	86.473	2.06E-01
755	0.755	1229.67778	58.05154	35.00000	0.00806	79.92494	5.15728	55.273	60.430	56.46102	85.806	2.12E-01
760	0.76	1211.81925	58.32761	37.00000	0.00790	80.07904	5.02039	57.965	62.986	52.91784	85.002	2.06E-01
765	0.765	1190.90381	58.59603	37.00000	0.00820	80.22875	4.85246	57.346	62.199	43.61031	84.208	1.67E-01
770	0.77	1172.11416	58.85822	38.00000	0.00775	80.37479	4.72219	58.321	63.043	36.30588	83.415	1.40E-01
775	0.775	1127.07185	59.11979	38.00000	0.00775	80.52031	4.46167	56.439	60.901	40.08622	82.679	1.48E-01
780	0.78	1145.53852	59.37644	38.00000	0.00805	80.66318	4.47039	57.720	62.190	30.06985	81.908	1.12E-01
785	0.785	1148.84080	59.54253	38.00000	0.00823	80.75821	4.42985	58.121	62.551	4.77021	81.028	1.78E-02
790	0.79	1135.94615	59.27215	38.00000	0.00834	80.62533	4.27782	57.121	61.398	0.85058	80.157	3.08E-03
795	0.795	1083.73172	59.59532	38.00000	0.00743	80.80455	4.03433	54.896	58.930	0.21000	79.223	7.22E-04
800	0.8	1090.53775	59.83049	38.00000	0.00743	80.93493	3.99968	55.546	59.546	0.05386	78.404	1.86E-04
805	0.805	1066.23105	60.24545	38.00000	0.00801	81.15911	3.87300	54.858	58.731	0.00334	77.538	1.12E-05
810	0.81	1068.34815	60.14277	38.00000	0.00805	81.11442	3.81009	54.844	58.654	0.00000	76.850	0.00E+00
815	0.815	1076.35474	56.23004	38.00000	0.00770	79.04163	3.55272	50.344	53.896	0.00000	76.012	0.00E+00
820	0.82	1027.57784	55.87138	37.00000	0.00770	78.88599	3.31621	46.419	49.735	0.00000	75.106	0.00E+00
825	0.825	1038.66545	57.05001	37.00000	0.00792	79.51983	3.36428	48.294	51.658	0.00000	74.452	0.00E+00
830	0.83	1031.99447	58.07388	37.00000	0.00645	80.05714	3.33838	49.128	52.467	0.00000	73.617	0.00E+00
835	0.835	1012.50106	60.66774	37.00000	0.00645	81.41736	3.35588	51.204	54.560	0.00000	72.733	0.00E+00
840	0.84	1006.15130	61.76291	37.00000	0.00809	81.99348	3.33022	52.216	55.546	0.00000	72.078	0.00E+00
845	0.845	997.07970	62.38684	37.00000	0.00800	82.32040	3.27692	52.473	55.750	0.00000	71.284	0.00E+00
850	0.85	902.34544	62.65835	37.00000	0.00558	82.46464	2.90633	47.726	50.632	0.00000	70.610	0.00E+00
855	0.855	750.93610	63.00286	37.00000	0.00558	82.64546	2.44841	40.051	42.500	0.00000	69.756	0.00E+00
860	0.86	968.00760	63.36696	37.00000	0.00780	82.83726	3.06896	52.065	55.134	0.02661	69.886	7.66E-05
865	0.865	955.51225	63.62615	37.00000	0.00752	82.97601	2.96677	51.683	54.650	0.02103	67.751	5.82E-05
870	0.87	939.27618	63.85359	37.00000	0.00752	83.09876	2.90634	51.065	53.972	0.12343	67.984	3.39E-04
875	0.875	924.65378	64.06292	37.00000	0.00751	83.21306	2.82098	50.507	53.328	0.00000	69.139	0.00E+00
880	0.88	938.70871	64.22033	37.00000	0.00671	83.30224	2.82775	51.427	54.255	0.06456	69.188	1.82E-04
885	0.885	931.96131	64.28355	37.00000	0.00671	83.34745	2.75758	51.137	53.894	0.00303	64.263	7.87E-06
890	0.89	922.78114	63.85407	37.00000	0.00782	83.14956	2.67619	50.213	52.889	0.05181	63.881	1.31E-04
895	0.895	908.75421	58.11609	37.00000	0.00722	80.17815	2.38423	43.404	45.788	0.11435	63.336	2.49E-04
900	0.9	896.21563	47.45395	37.00000	0.00722	74.20465	1.91341	32.387	34.300	0.12906	63.917	2.11E-04
905	0.905	902.21070	52.45227	37.00000	0.00699	77.18828	2.07545	37.456	39.532	0.00000	63.500	0.00E+00
910	0.91	862.13625	50.11440	37.00000	0.00699	75.82434	1.88366	33.610	35.494	0.13666	63.000	2.29E-04
915	0.915	881.40282	51.71365	37.00000	0.00696	76.71658	1.94673	35.863	37.810	0.13707	62.750	2.44E-04
920	0.92	865.94112	56.58045	37.00000	0.00764	79.48746	2.03195	39.947	41.979	0.05116	62.500	1.01E-04
925	0.925	829.72602	54.51864	37.00000	0.00764	78.42707	1.85812	36.407	38.265	0.07725	62.250	1.38E-04
930	0.93	839.32533	23.31238	37.00000	0.00755	56.35523	0.92488	11.404	12.329	0.34592	62.000	1.93E-04
935	0.935	834.94723	4.02381	37.00000	0.00755	28.76042	0.29967	1.066	1.366	0.01688	61.750	8.79E-07
940	0.94	821.56152	9.87045	37.00000	0.00741	40.94288	0.46170	3.499	3.960	0.23942	61.500	4.07E-05
945	0.945	810.65097	8.83115	37.00000	0.00741	39.04670	0.42996	2.958	3.388	0.00000	61.250	0.00E+00
950	0.95	809.89535	14.17650	37.00000	0.00711	46.72129	0.57945	5.594	6.174	0.11029	61.000	2.98E-05
955	0.955	784.99123	24.77097	37.00000	0.00662	58.27286	0.83652	11.700	12.537	0.00000	60.750	0.00E+00
960	0.96	795.27955	39.17057	37.00000	0.00662	68.95971	1.20431	22.080	23.284	0.08717	60.500	9.21E-05
965	0.965	776.32176	49.19507	37.00000	0.00734	75.35231	1.39588	29.557	30.953	0.00000	60.250	0.00E+00

1.20E-01	4.38E+17	1.14E+18	0.93	0.4185	98952	495	256787	1284			600	0.302
1.24E-01	4.70E+17	1.19E+18	0.935	0.42075	106761	534	270541	1353			**605**	**0.408**
1.23E-01	4.80E+17	1.19E+18	0.94	0.423	109714	549	271741	1359			610	0.514
1.22E-01	4.94E+17	1.19E+18	0.91	0.4095	109297	546	262449	1312			**615**	**0.5974**
1.18E-01	4.98E+17	1.16E+18	0.88	0.396	106514	533	247671	1238			620	0.6808
1.13E-01	5.03E+17	1.12E+18	0.83	0.3735	101364	507	226111	1131			**625**	**0.73755**
1.16E-01	5.33E+17	1.16E+18	0.78	0.351	101003	505	219127	1096			630	0.7943
1.20E-01	5.75E+17	1.20E+18	0.755	0.33975	105571	528	221054	1105			**635**	**0.82665**
1.16E-01	5.74E+17	1.17E+18	0.73	0.3285	101805	509	207582	1038			640	0.859
1.14E-01	5.84E+17	1.16E+18	0.725	0.32625	102927	515	204806	1024			**645**	**0.87925**
1.07E-01	5.63E+17	1.10E+18	0.72	0.324	98522	493	191866	959			650	0.8995
1.08E-01	5.83E+17	1.12E+18	0.75	0.3375	106333	532	203626	1018			**655**	**0.90785**
1.06E-01	5.89E+17	1.11E+18	0.78	0.351	111587	558	210407	1052			660	0.9162
1.09E-01	6.24E+17	1.15E+18	0.815	0.36675	123641	618	227975	1140			**665**	**0.92045**
1.09E-01	6.40E+17	1.15E+18	0.85	0.3825	132209	661	238041	1190			670	0.9247
1.06E-01	6.47E+17	1.13E+18	0.875	0.39375	137614	688	239496	1197			**675**	**0.9279**
1.01E-01	6.49E+17	1.09E+18	0.9	0.405	141835	709	238070	1190			680	0.9311
9.91E-02	6.70E+17	1.07E+18	0.9	0.405	146430	732	234712	1174			**685**	**0.93215**
1.00E-01	7.17E+17	1.09E+18	0.9	0.405	156731	784	239109	1196			690	0.9332
9.76E-02	7.35E+17	1.07E+18	0.875	0.39375	156237	781	228030	1140			**695**	**0.9343**
1.03E-01	8.19E+17	1.14E+18	0.85	0.3825	169247	846	234478	1172			700	0.9354
1.14E-01	9.66E+17	1.27E+18	0.815	0.36675	191236	956	251846	1259			**705**	**0.93755**
1.22E-01	1.08E+18	1.37E+18	0.78	0.351	204885	1024	259727	1299			710	0.9397
1.24E-01	1.13E+18	1.40E+18	0.755	0.33975	207928	1040	256265	1281			**715**	**0.94295**
1.16E-01	1.09E+18	1.32E+18	0.73	0.3285	193114	966	233559	1168			720	0.9462
1.42E-01	1.39E+18	1.63E+18	0.72	0.324	242925	1215	285569	1428			**725**	**0.9517**
1.73E-01	1.73E+18	1.99E+18	0.71	0.3195	298335	1492	344023	1720			730	0.9572
2.19E-01	2.25E+18	2.54E+18	0.725	0.32625	396815	1984	447958	2240			**735**	**0.9605**
2.30E-01	2.41E+18	2.69E+18	0.74	0.333	433590	2168	484243	2421			740	0.9638
2.29E-01	2.44E+18	2.70E+18	0.77	0.3465	455869	2279	504533	2523			**745**	**0.96715**
2.26E-01	2.45E+18	2.69E+18	0.8	0.36	475338	2377	522178	2611			750	0.9705
2.32E-01	2.53E+18	2.76E+18	0.84	0.378	516169	2581	564331	2822			**755**	**0.97385**
2.24E-01	2.48E+18	2.69E+18	0.88	0.396	530010	2650	575915	2880			760	0.9772
1.81E-01	2.02E+18	2.19E+18	0.91	0.4095	445595	2228	483300	2417			**765**	**0.98285**
1.51E-01	1.70E+18	1.84E+18	0.94	0.423	388558	1943	420019	2100			770	0.9885
1.60E-01	1.81E+18	1.96E+18	0.96	0.432	422991	2115	456430	2282			**775**	**0.99195**
1.21E-01	1.39E+18	1.49E+18	0.98	0.441	330285	1651	355865	1779			780	0.9954
1.91E-02	2.21E+17	2.37E+17	0.99	0.4455	53063	265	57108	286			**785**	**0.99655**
3.31E-03	3.85E+16	4.14E+16	1	0.45	9351	47	10051	50			790	0.9977
7.75E-04	9.08E+15	9.75E+15	0.98	0.441	2163	11	2322	12			**795**	**0.99885**
1.99E-04	2.35E+15	2.52E+15	0.96	0.432	548	3	587	3			800	1
1.20E-05	1.43E+14	1.53E+14	0.94	0.423	33	0	35	0			**805**	**1**
0.00E+00	0.00E+00	0.00E+00	0.92	0.414	0	0	0	0			810	1
0.00E+00	0.00E+00	0.00E+00	0.88	0.396	0	0	0	0			**815**	**1**
0.00E+00	0.00E+00	0.00E+00	0.84	0.378	0	0	0	0			820	1
0.00E+00	0.00E+00	0.00E+00	0.835	0.37575	0	0	0	0			**825**	**1**
0.00E+00	0.00E+00	0.00E+00	0.83	0.3735	0	0	0	0			830	1
0.00E+00	0.00E+00	0.00E+00	0.83	0.3735	0	0	0	0			**835**	**1**
0.00E+00	0.00E+00	0.00E+00	0.83	0.3735	0	0	0	0			840	1
0.00E+00	0.00E+00	0.00E+00	0.825	0.37125	0	0	0	0			**845**	**1**
0.00E+00	0.00E+00	0.00E+00	0.82	0.369	0	0	0	0			850	1
0.00E+00	0.00E+00	0.00E+00	0.82	0.369	0	0	0	0			**855**	**1**
8.11E-05	1.04E+15	1.10E+15	0.82	0.369	208	1	220	1			860	1
6.16E-05	7.97E+14	8.42E+14	0.825	0.37125	160	1	169	1			**865**	**1**
3.58E-04	4.66E+15	4.93E+15	0.83	0.3735	940	5	994	5			870	1
0.00E+00	0.00E+00	0.00E+00	0.835	0.37575	0	0	0	0			**875**	**1**
1.92E-04	2.53E+15	2.67E+15	0.84	0.378	516	3	545	3			880	1
8.29E-06	1.10E+14	1.16E+14	0.83	0.3735	22	0	23	0			**885**	**1**
1.38E-04	1.85E+15	1.95E+15	0.82	0.369	369	2	388	2			890	1
2.62E-04	3.52E+15	3.71E+15	0.795	0.35775	680	3	717	4			**895**	**1**
2.24E-04	3.01E+15	3.19E+15	0.77	0.3465	563	3	596	3			900	1
0.00E+00	0.00E+00	0.00E+00	0.735	0.33075	0	0	0	0			905	1
2.42E-04	3.29E+15	3.48E+15	0.7	0.315	560	3	592	3			910	1
2.57E-04	3.53E+15	3.72E+15	0.665	0.29925	570	3	601	3			915	1
1.06E-04	1.47E+15	1.54E+15	0.63	0.2835	225	1	236	1			920	1
1.46E-04	2.03E+15	2.13E+15	0.595	0.26775	293	1	308	2			925	1
2.09E-04	2.85E+15	3.08E+15	0.56	0.252	387	2	419	2			930	1
1.13E-06	1.30E+13	1.66E+13	0.525	0.23625	2	0	2	0			935	1
4.61E-05	6.06E+14	6.86E+14	0.49	0.2205	72	0	82	0			940	1
0.00E+00	0.00E+00	0.00E+00	0.455	0.20475	0	0	0	0			945	1
3.29E-05	4.47E+14	4.94E+14	0.42	0.189	46	0	50	0			950	1
0.00E+00	0.00E+00	0.00E+00	0.395	0.17775	0	0	0	0			955	1
9.71E-05	1.40E+15	1.47E+15	0.37	0.1665	126	1	133	1			960	1
0.00E+00	0.00E+00	0.00E+00	0.345	0.15525	0	0	0	0			965	1

0.2183	0.0522	23907	120	62040	310	17281	86	44845	224	4132	21	10723	54
0.17475	0.05385	34847	174	88305	442	14925	75	37822	189	4599	23	11655	58
0.1312	0.0555	45115	226	111740	559	11516	58	28522	143	4871	24	12065	60
0.1171	0.0576	52235	261	125429	627	10239	51	24586	123	5036	25	12094	60
0.103	0.0597	58012	290	134891	674	8777	44	20408	102	5087	25	11829	59
0.0986	0.06245	59809	299	133415	667	7996	40	17836	89	5064	25	11297	56
0.0942	0.0652	64181	321	139242	696	7612	38	16513	83	5268	26	11430	57
0.0886	0.0638	69816	349	146188	731	7483	37	15668	78	5388	27	11283	56
0.083	0.0624	69961	350	142650	713	6760	34	13783	69	5082	25	10362	52
0.07095	0.05395	72399	362	144060	720	5842	29	11625	58	4442	22	8839	44
0.0589	0.0455	70897	354	138067	690	4642	23	9041	45	3586	18	6984	35
0.0425	0.0324	77227	386	147889	739	3615	18	6923	35	2756	14	5278	26
0.0261	0.0193	81789	409	154220	771	2330	12	4393	22	1723	9	3249	16
0.01665	0.012	91044	455	167871	839	1647	8	3037	15	1187	6	2189	11
0.0072	0.0047	97803	489	176093	880	762	4	1371	7	497	2	895	4
0.00555	0.00355	102154	511	177783	889	611	3	1063	5	391	2	680	3
0.0039	0.0024	105650	528	177334	887	443	2	743	4	272	1	457	2
0.0061	0.0037	109196	546	175029	875	715	4	1145	6	433	2	695	3
0.0083	0.005	117009	585	178509	893	1041	5	1588	8	627	3	956	5
0.0238	0.016	116778	584	170439	852	2975	15	4342	22	2000	10	2919	15
0.0393	0.027	126651	633	175464	877	5321	27	7372	37	3656	18	5065	25
0.08945	0.06795	143435	717	188894	944	13685	68	18022	90	10396	52	13690	68
0.1396	0.1089	154024	770	195253	976	22882	114	29006	145	17850	89	22627	113
0.21365	0.1766	156853	784	193316	967	35539	178	43801	219	29376	147	36205	181
0.2877	0.2443	146179	731	176795	884	44447	222	53756	269	37742	189	45647	228
0.3677	0.3203	184954	925	217421	1087	71459	357	84003	420	62247	311	73174	366
0.4477	0.3963	228453	1142	263439	1317	106852	534	123215	616	94584	473	109069	545
0.5258	0.46545	304913	1525	344211	1721	166916	835	188429	942	147758	739	166802	834
0.6039	0.5346	334316	1672	373371	1867	209476	1047	233948	1170	185438	927	207101	1036
0.66585	0.58425	352715	1764	390368	1952	242832	1214	268755	1344	213073	1065	235819	1179
0.7278	0.6339	369053	1845	405419	2027	276761	1384	304033	1520	241053	1205	264807	1324
0.7703	0.6685	402137	2011	439659	2198	318084	1590	347763	1739	276047	1380	301804	1509
0.8128	0.7031	414341	2072	450227	2251	344634	1723	374483	1872	298120	1491	323940	1620
0.8349	0.7291	350363	1752	380009	1900	297622	1488	322806	1614	259907	1300	281899	1409
0.857	0.7551	307271	1536	332151	1661	266395	1332	287965	1440	234720	1174	253725	1269
0.868	0.7784	335669	1678	362204	1811	293725	1469	316945	1585	263405	1317	284228	1421
0.879	0.8017	263012	1315	283383	1417	232256	1161	250245	1251	211832	1059	228238	1141
0.8841	0.8196	42304	212	45529	228	37531	188	40391	202	34793	174	37444	187
0.8892	0.8375	7464	37	8023	40	6652	33	7150	36	6265	31	6734	34
0.89125	0.85225	1728	9	1855	9	1542	8	1655	8	1475	7	1583	8
0.8933	0.867	438	2	470	2	391	2	419	2	380	2	407	2
0.89415	0.8685	26	0	28	0	23	0	25	0	23	0	24	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	166	1	176	1	149	1	157	1	144	1	153	1
0.895	0.87	128	1	135	1	114	1	121	1	111	1	118	1
0.895	0.87	752	4	795	4	673	3	712	4	655	3	692	3
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	413	2	436	2	370	2	390	2	359	2	379	2
0.895	0.87	18	0	19	0	16	0	17	0	15	0	16	0
0.895	0.87	295	1	311	2	264	1	278	1	257	1	270	1
0.895	0.87	544	3	574	3	487	2	513	3	473	2	499	2
0.895	0.87	450	2	477	2	403	2	427	2	392	2	415	2
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	448	2	473	2	401	2	424	2	390	2	412	2
0.895	0.87	456	2	481	2	408	2	431	2	397	2	419	2
0.895	0.87	180	1	189	1	161	1	169	1	157	1	165	1
0.895	0.87	234	1	246	1	210	1	220	1	204	1	214	1
0.895	0.87	310	2	335	2	277	1	300	1	269	1	291	1
0.895	0.87	1	0	2	0	1	0	2	0	1	0	1	0
0.895	0.87	58	0	65	0	52	0	58	0	50	0	57	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	37	0	40	0	33	0	36	0	32	0	35	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0
0.895	0.87	101	1	106	1	90	0	95	0	87	0	92	0
0.895	0.87	0	0	0	0	0	0	0	0	0	0	0	0

119.53434	138.386441	39.126178	183.164194	278.371779	107.010097	310.199128	359.121516	101.534892		475.322602	722.392271	277.69793
174.234547	119.521312	43.5482787	300.580405	210.112089	119.104542	441.523414	302.875971	110.354605		761.693298	532.439798	301.819846
225.572574	92.2170176	46.1240399	414.703297	123.199789	126.149249	558.69866	228.403317	114.240126		1027.13806	305.141514	312.446744
261.175652	81.9933112	47.6871242	494.404119	88.7967746	130.424285	627.147186	196.886172	114.508552		1187.18628	213.222966	313.180889
290.059877	70.2844734	48.1674462	561.027314	53.4658729	131.737965	674.457475	163.427941	112.000648		1304.52054	124.320737	306.321772
299.045303	64.0289667	47.9500584	582.666826	36.0628825	131.14341	667.073301	142.827905	106.961064		1299.74114	80.4446209	292.538509
320.907229	60.9536758	49.8831319	629.181409	21.1692322	136.430366	696.210272	132.239387	108.221772		1365.01306	45.9267838	295.986545
349.081351	59.9228913	51.0195749	692.502232	14.6593366	139.538537	730.937876	125.47193	106.829367		1450.02335	30.6950351	292.178319
349.802982	54.1330499	48.1200547	701.422226	6.93550416	131.60835	713.250473	110.377628	98.1170932		1430.20431	14.1415365	268.35025
361.995324	46.7839669	42.062319	745.145723	4.51803945	115.040442	720.302274	93.0912515	83.6960645		1482.69915	8.99004455	228.908736
354.483503	37.1761332	33.9560713	747.708734	1.93751151	92.8698549	690.33462	72.398212	66.1273412		1456.11635	3.77318342	180.858278
386.137208	28.9514649	26.0965888	841.617464	2.58763217	71.3741705	739.44637	55.4415769	49.9745363		1611.68353	4.95527284	136.680357
408.944524	18.6581542	16.3133291	919.548927	3.23655199	44.6169551	771.098687	35.1814912	30.7601298		1733.88547	6.10278618	84.1289551
455.219884	13.1883152	11.2386319	1040.84962	3.19580174	30.7376582	839.356634	24.3172592	20.7223379		1919.16931	5.8925752	56.6755941
489.015274	6.09829071	4.70685266	1136.47839	2.99986892	12.873242	880.465592	10.9798925	8.47462653		2046.21444	5.40122467	23.1781036
510.768342	4.89293943	3.70051636	1190.06238	2.64309062	10.1209123	888.914477	8.51541558	6.4401849		2071.12225	4.59989652	17.6139057
528.250616	3.5437441	2.57849389	1233.90684	2.23003993	7.05218079	886.668241	5.94817166	4.32799995		2071.11165	3.74312025	11.8370799
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585.045629	8.33387844	5.93603144	1358.89455	5.64165901	16.235046	892.545599	12.7141648	9.05600943		2073.12949	8.60691486	24.7681858
583.888818	23.8218139	18.9354213	1323.78388	10.0126882	51.7883771	852.193368	34.7682489	27.636495		1932.07988	14.6136494	75.5858138
633.255672	42.6116482	34.6143887	1400.62526	15.6007578	94.670353	877.322219	59.0348376	47.9553104		1940.44794	21.6135315	131.157774
717.173714	109.588335	98.4306981	1438.63458	10.8861102	269.207959	944.471474	144.320762	129.626874		1894.58885	14.3363042	354.5295
770.12239	183.235662	169.008903	1387.07719	4.44040251	462.239349	976.263708	232.282984	214.248099		1758.36092	5.62898038	585.96855
784.26469	284.597417	278.147958	1148.30878	-41.719169	760.734664	966.579703	350.756691	342.80795		1415.25173	-51.4174647	937.579743
730.896384	355.931801	357.361297	825.600357	-81.6786462	977.383147	883.975422	430.478205	432.207096		998.514209	-98.785433	1182.08641
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37.3184656	53.2693406	59.3225488	-60.2080342	-30.3667645	162.247171	40.1132881	57.2587423	63.7652821		-64.7170825	-32.6409661	174.398046
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970	0.97	770.46410	58.03232	37.00000	0.00734	80.32804	1.58344	36.851	38.435	0.09284	60.000	1.62E-04
975	0.975	753.11526	58.46016	37.00000	0.00708	80.51942	1.53568	36.369	37.905	0.10841	59.750	1.86E-04
980	0.98	751.69642	62.75749	37.00000	0.00708	82.72274	1.61375	40.020	41.633	0.06559	59.500	1.24E-04
985	0.985	744.08398	67.01670	37.00000	0.00683	84.84671	1.66955	43.369	45.038	0.00000	59.250	0.00E+00
990	0.99	731.48558	68.92233	37.00000	0.00683	85.77799	1.66293	44.326	45.988	0.11578	59.000	2.39E-04
995	0.995	731.22190	69.52750	37.00000	0.00676	86.07157	1.64626	44.848	46.494	0.00000	59.500	0.00E+00
1000	1	724.92750	69.75543	37.00000	0.00676	86.18406	1.60984	44.667	46.277	0.03743	58.000	7.67E-05

INPUT DATA FILES:

	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTF	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN
	roch23KM	roch23KM		roch23KM	roch23KM	roch7KM	roch7KM	roch7KM	roch7KM	roch7KM	roch5+KM	roch5+KM
	Es-roch23	T1-roch23	SLd-roch23	T2-roch23	SLu-roch23	Es-roch7	T1-roch7	SLd-roch7	T2-roch7	SLu-roch7	Es-roch5+	T1-roch5+
wl(nm)	Es(Watts/m^2*um)	(%)	(W/m^2-um-sr)	(%)	(Watts/m^2*um*sr)	(W/m^2-um)	%	(W/m^2-um-sr	%	(W/m^2-um-sr	(W/m^2-um)	%
400	1581.18675	17.72444995	0.002164903	49.6613398	35.998560	1590.24	0.80115	0.004323724	13.6428	29.2859	1590.24	1.6939
405	1688.698561	18.614392	0.002511711	50.6387353	37.248911	1595.51	0.845107	0.004781321	13.9377	28.4884	1595.51	1.84735
410	1374.125693	19.50718835	0.001666576	51.5892357	28.672233	1485.62	0.890416	0.002765252	14.2324	26.0613	1485.62	1.92807
415	1840.539088	20.3856543	1.96728E-07	52.5036633	37.739760	1669.09	0.937091	4.03888E-07	14.527	28.3073	1669.09	2.05439
420	1456.854909	21.25164495	7.9242E-23	53.38405965	28.796976	1702.55	0.985152	2.81073E-23	14.8213	28.0079	1702.55	2.18731
425	1533.498837	22.11123555	7.40888E-06	54.23775615	28.953787	1648.38	1.03462	9.55391E-06	15.1157	26.3719	1648.38	2.32721
430	1162.740698	22.9771383	0.003457164	55.0697893	21.307899	1548.01	1.08552	0.0047159	15.4101	23.7295	1548.01	2.4745
435	1775.586651	23.7875499	0.004341902	55.8613032	31.548370	1623.95	1.12027	0.005756667	15.6065	24.9094	1623.95	2.57703
440	1673.480083	24.6406734	0.00274727	56.6405863	28.821046	1709.86	1.17235	0.003237646	15.8935	25.5279	1709.86	2.73465
445	1928.96352	25.45498905	0.001483002	57.39069285	32.267217	1891.63	1.2158	0.00152466	16.1206	27.0109	1891.63	2.87689
450	2029.538296	26.3179898	6.60221E-06	58.1350386	33.183692	2089.17	1.26604	7.14743E-06	16.3937	29.4884	2089.17	3.02511
455	1912.725429	27.12490115	0.00093679	58.84286765	30.284819	2039.95	1.32364	0.000821418	16.6902	28.0359	1937.94	3.14751
460	1989.511503	27.922678	0.004332425	59.52915845	30.338869	1985.98	1.36297	0.004776085	16.8884	26.8825	1985.98	3.33971
465	1840.589631	28.7085712	0.005578272	60.19763055	27.238877	1975.99	1.40308	0.006166319	17.0871	26.0864	1975.99	3.47391
470	1892.170005	29.51634225	0.005770451	60.8582616	27.160335	1990.65	1.44866	0.005891004	17.3134	25.3298	1888.17	3.5483
475	2003.228942	30.263488	0.005581061	61.48495675	28.054069	1909.46	1.50692	0.005689898	17.5867	24.3231	1909.46	3.83254
480	2022.472361	31.03440255	0.003559332	62.1016473	27.429239	2011.36	1.54995	0.003269743	17.7879	24.9922	2011.36	3.98599
485	1857.705624	31.81493875	0.000838004	62.71218955	24.571026	1694.92	1.57629	0.000608783	17.911	20.5419	1694.92	4.09992
490	2032.386872	32.5496584	2.95806E-05	63.29489645	25.987898	1937.32	1.63473	2.0381E-05	18.1767	23.0893	1937.32	4.30123
495	2032.345063	33.3013937	0.001332967	63.86636495	25.302288	1878.53	1.676525	0.000514243	18.36205	22.00625	1884.58	4.48494
500	1843.9078	34.01441948	0.001408066	64.43524955	22.318884	1819.74	1.71832	0.001008105	18.5474	20.9232	1819.74	4.62991
505	1823.258573	34.72744525	0.004286895	64.96916715	21.447794	1924.26	1.68665	0.003658722	18.2051	20.4255	1924.26	4.60063
510	1872.261296	35.45752765	0.007356097	65.5070454	21.336859	1901.44	1.78771	0.006559355	18.806	20.7263	1901.44	4.93766
515	1764.448668	36.19232775	0.007481058	66.03592335	19.718091	1752.49	1.8787	0.00656555	19.229	19.1959	1752.49	5.2555
520	1797.243817	36.8936077	0.007064274	66.55038595	19.636553	1836.26	1.93015	0.0060904	19.441	19.6884	1836.26	5.4702
525	1879.266413	37.58319465	0.00571585	67.04889835	19.844763	1648.73	1.96548	0.004745312	19.5865	17.5617	1648.73	5.64484
530	1836.855294	38.2827774	0.004989674	67.5442308	18.866925	1745.06	2.03568	0.004050481	19.8666	18.3876	1745.06	5.92643
535	1809.668223	38.9760926	0.004035136	68.02903715	18.236425	1896.84	2.06413	0.003106193	19.9786	19.4462	1896.84	6.05083
540	1718.014218	39.65670315	0.006160629	68.5057342	16.734350	1776.1	1.97614	0.004957587	19.4657	16.5617	1776.1	5.87447
545	1888.626969	40.31451045	0.006655826	68.96859705	18.078301	1801.84	2.05962	0.005345981	19.8638	16.891	1801.84	6.21159
550	1824.693025	40.98804595	0.007965022	69.4262415	16.990801	1825.86	2.16669	0.006459847	20.3788	17.692	1806.58	6.78896
555	1847.150136	41.54434055	0.007858865	69.79982555	16.718494	1797.64	2.2583	0.006300077	20.7225	17.4857	1797.64	6.92341
560	1779.237092	42.08217115	0.007647074	70.16064825	15.751669	1789.67	2.30766	0.006057456	20.906	17.0637	1789.67	7.14101
565	1838.724519	42.59375335	0.007995118	70.5093414	15.912641	1750.76	2.32384	0.006308136	20.9677	16.5498	1750.76	7.22526
570	1788.140606	42.97071245	0.007073733	70.7634181	15.049927	1806.58	2.23847	0.005494564	20.366	15.4821	1806.58	7.02716
575	1787.420847	43.5493976	0.004948961	71.1396605	14.698588	1785.99	2.26313	0.003652402	20.56	15.3119	1785.99	7.13982
580	1789.432473	44.14198995	0.002576118	71.52680755	14.446249	1810.32	2.43685	0.001715228	21.3784	16.1767	1810.32	7.76487
585	1782.348791	44.6138561	0.001665972	71.8367338	14.054258	1745.7	2.40945	0.001019924	21.1949	15.1421	1745.7	7.71649
590	1668.96214	44.21366305	0.006248777	71.6050804	12.754203	1747.49	1.91775	0.004615983	17.6266	10.7874	1747.49	6.2065
595	1728.588619	44.81757285	0.005814723	71.9905078	12.851435	1739.11	2.08434	0.004244498	18.6738	11.6422	1739.11	6.78124
600	1727.674111	45.96221295	0.004880307	72.70736695	12.721459	1701.04	2.60141	0.003473592	21.9169	14.4401	1701.04	8.55384
605	1737.481106	46.6317311	0.007111233	73.1208533	12.566687	1708.67	2.67104	0.005241151	22.1892	14.5937	1708.67	8.83067
610	1676.866262	47.11243805	0.007913462	73.42941465	11.850930	1661.89	2.70162	0.005844055	22.2925	14.1339	1661.89	8.98123
615	1657.641455	47.58567365	0.008262747	73.72805475	11.500383	1668.7	2.76367	0.006157708	22.5003	13.8263	1668.7	9.29146
620	1657.02525	48.04917425	0.008321711	74.0180671	11.237597	1649.66	2.7953	0.006031672	22.6052	13.6516	1649.66	9.4518
625	1610.13936	48.5096559	0.008565266	74.3044138	10.674533	1597.77	2.77722	0.006171187	22.4992	12.8726	1597.77	9.44492
630	1627.511469	48.8871023	0.008368295	74.5396465	10.556150	1605.88	2.74412	0.005382333	22.2144	12.1278	1605.88	9.44402
635	1619.340404	49.3677437	0.007122142	74.8352796	10.316166	1606.93	2.81549	0.004993049	22.5928	12.3049	1606.93	9.74802
640	1540.42875	49.86035375	0.007130866	75.1318991	9.618525	1565.41	2.85548	0.00498456	22.7387	11.9253	1565.41	9.94688
645	1552.691144	50.13640225	0.007271094	75.3106624	9.469974	1574.63	2.64692	0.005046789	21.3379	10.5704	1574.63	9.27611
650	1505.227598	50.14350115	0.008448437	75.33163135	8.946164	1524.71	2.6883	0.005936946	21.3642	9.94633	1533.66	9.06321
655	1538.271126	50.7377118	0.008099554	75.6848216	8.973248	1465.85	2.83237	0.005573606	22.1767	10.0077	1465.85	10.1189
660	1487.505124	51.54191255	0.008133306	76.1564851	8.585292	1510.31	3.06223	0.005554032	23.4113	11.1961	1510.31	11.0109
665	1494.614831	52.0813316	0.008144767	76.4763564	8.479282	1492.31	3.15521	0.00555152	23.7462	11.2005	1492.31	11.4205
670	1492.437313	52.5309324	0.008531811	76.744315	8.264093	1471.96	3.21606	0.005785446	23.9413	11.0382	1471.96	11.7187
675	1470.408285	52.9703438	0.008659312	77.0044774	7.988487	1464.5	3.25521	0.00584236	24.0605	10.8839	1464.5	11.942
680	1448.863408	53.38775515	0.008282954	77.25091275	7.741688	1448.53	3.26681	0.005560678	24.0923	10.5804	1448.53	12.0671
685	1434.181681	53.78942785	0.008242596	77.48830915	7.479907	1415.23	3.14553	0.005506463	23.0872	9.53653	1415.23	11.6981
690	1423.972313	54.0848583	0.00843828	77.6668578	7.308884	1408.82	2.8814	0.00560993	21.4602	8.25064	1408.82	10.7936
695	1391.135647	52.57140995	0.008272115	76.8377036	6.790067	1391.32	2.47	0.005472193	18.8348	6.621	1391.32	9.31356
700	1365.210551	53.2811701	0.007492092	77.2467792	6.591375	1364.55	2.52596	0.004903365	19.194	6.46715	1364.55	9.56066

1.69E-04	2.49E+15	2.60E+15	0.32	0.144	194	1	202	1			970	1
1.94E-04	2.87E+15	2.99E+15	0.3	0.135	209	1	218	1			975	1
1.29E-04	1.91E+15	1.99E+15	0.28	0.126	130	1	136	1			980	1
0.00E+00	0.00E+00	0.00E+00	0.255	0.11475	0	0	0	0			985	1
2.48E-04	3.75E+15	3.89E+15	0.23	0.1035	210	1	217	1			990	1
0.00E+00	0.00E+00	0.00E+00	0.215	0.09675	0	0	0	0			995	1
7.95E-05	1.21E+15	1.26E+15	0.19	0.0855	56	0	58	0			1000	1
LOWTRAN/MODTRAN	LOWTRAN/MODTRAN	LOWTRAN/MODTRAN		MEASURED	MEASURED	MEASURED	MEASURED		MEASURED	MEASURED	MEASURED	MEASURED
roch5+KM	roch5+KM	roch5+KM		FILTER	FILTER	FILTER	FILTER		MACBETH TARGET	MACBETH TARGET	MACBETH TARGET	MACBETH TARGET
SLd-roch5+	T2-roch5+	SLu-roch5+		650BPfilter	VISfilter	Tiffen Yellow #12	hot mirror		**Dark Skin**	**Light Skin**	**Blue Sky**	**Foliage**
w/m^2-um-sr	%	w/m^2-um-sr		trans	trans	trans	trans		reflect	reflect	reflect	reflect
0.00642775	18.6611	52.6352		0	84.22574997	-0.02	91.38		7.4100	18.1500	25.5200	5.5800
0.00728362	19.3255	49.3782		0	84.18455124	-0.02	90.41		7.7700	19.5100	29.2800	5.6400
0.0046595	19.662	47.7334		0	82.2687149	-0.02	87.42		7.7900	20.1600	31.4800	5.6800
2.9799E-07	20.1726	52.1467		0	75.31733513	-0.02	89.22		7.6100	20.3400	32.4600	5.7100
5.9104E-23	20.6904	51.9524		0	81.66637421	-0.02	88.08		7.3500	20.4200	32.9300	5.7700
0.000013096	21.216	49.3018		0	88.93973827	-0.02	92.35		7.0400	20.5000	33.0700	5.8200
0.00865927	21.7498	44.432		0	84.60683823	-0.02	89.44		6.7600	20.8600	33.0900	5.9300
0.01070214	22.1105	47.2483		0	89.36727047	-0.02	91.94		6.5400	21.0600	33.0200	6.0400
0.00657793	22.6482	48.8048		0	85.20274162	-0.03	91.31		6.3600	21.4000	32.8900	6.2100
0.00330629	23.1093	51.7		0	90.59720039	-0.03	92.97		6.2300	21.8600	32.6900	6.4000
0.000010123	23.5964	56.8066		0	85.0748539	-0.03	88.50		6.1500	22.3900	32.4400	6.6400
0.00022961	23.9798	52.2822		0	89.61105347	-0.03	90.88		6.1000	23.0200	32.0800	6.8400
0.00987886	24.5647	52.4595		0	91.31135941	-0.02	92.85		6.0700	23.6600	31.5800	7.0100
0.01259064	24.9616	50.974		0	87.12232113	-0.02	93.24		6.0500	24.5000	31.0100	7.1400
0.01280922	25.1833	47.2713		0	81.5759182	-0.02	92.74		6.0600	25.3600	30.3400	7.2900
0.01208498	25.9805	48.2036		0	88.93609047	-0.02	90.77		6.1000	26.1000	29.6500	7.4100
0.00746383	26.3996	49.5646		0	92.15686321	0.03	93.43		6.1900	26.6500	28.8300	7.5200
0.00147229	26.708	40.8257		0	92.18277931	0.33	93.49		6.3400	27.0200	28.0100	7.6800
0.000038542	27.2348	45.9943		0	88.93492222	1.56	93.72		6.5300	27.1800	27.1000	7.8600
0.00242469	27.7013	44.921		0.005269051	88.88392448	4.75	93.73		6.6900	27.3400	26.2300	8.1000
0.00249273	28.0668	41.9589		0	92.9923296	11.04	93.02		6.8100	27.7700	25.4200	8.5300
0.00854512	27.6899	40.1728		24.83661175	91.65196419	20.07	92.76		6.9600	28.8000	24.6300	9.5000
0.01470555	28.7532	41.4615		36.50465012	92.18940735	31.14	90.57		7.2000	30.4000	23.8400	11.3100
0.01483156	29.5566	38.7707		35.42208672	91.21603966	42.23	91.47		7.5000	31.6500	22.9800	13.7800
0.01383523	30.045	39.7593		31.16543293	89.22486305	52.57	93.38		7.8000	31.7100	22.0600	16.2800
0.01107886	30.438	35.7301		67.83156395	92.36700535	61.24	90.60		8.0600	30.7500	21.2000	18.0600
0.0095679	31.0486	37.4972		37.44375706	93.32787991	68.42	89.68		8.2600	29.5800	20.4900	18.9000
0.00756288	31.3135	39.3369		38.47293854	92.67902374	73.89	92.88		8.3900	28.8600	19.9600	18.9100
0.01169709	30.6882	32.7634		66.54243469	93.64254475	78.03	93.42		8.4900	28.8700	19.5700	18.3200
0.0125513	31.5037	33.6235		84.97219086	91.96915627	80.97	92.54		8.5900	29.3200	19.2600	17.3200
0.01505143	32.8339	35.8071		83.59904289	91.34476185	83.07	93.71		8.7300	29.6500	18.9600	16.2100
0.01471005	33.0916	35.5564		85.1821661	93.70760918	84.55	93.83		8.9600	29.5100	18.5800	15.1100
0.01418849	33.5147	34.726		83.08010101	92.60921478	85.68	92.67		9.3100	29.0800	18.1500	13.9800
0.0148233	33.68	33.7308		77.25565434	90.04361629	86.40	93.14		9.8100	28.9800	17.6500	13.0900
0.01297904	32.8452	30.7503		73.05366993	91.6230917	86.99	93.95		10.4500	29.7600	17.1800	12.8100
0.00896037	33.2262	30.5248		72.26421833	94.12734509	87.52	93.01		11.1900	31.6800	16.7600	12.7800
0.00436394	34.6927	32.9033		74.53737259	93.25122833	87.95	92.57		11.9400	34.6700	16.4200	12.5400
0.00263895	34.4677	30.6315		77.86557674	91.28735065	88.24	93.32		12.6300	38.3700	16.1000	12.2300
0.01121899	28.7892	19.3689		79.32100296	89.81957436	88.48	92.25		13.2500	42.1200	15.8000	11.7600
0.01038719	30.5666	21.4868		78.82554531	89.31214809	88.72	89.59		13.7800	45.5700	15.5500	11.2500
0.00860426	36.035	29.3657		79.27594185	91.0517931	88.90	89.11		14.2100	48.3600	15.3000	10.7500
0.01257421	36.5657	29.8399		81.9955349	93.70415211	88.99	91.27		14.6200	50.4600	15.0600	10.3400
0.01400247	36.8206	28.9435		84.73324776	93.29102039	89.07	93.16		14.9800	52.0100	14.7800	10.0800
0.01483948	37.3385	28.1746		84.32905674	91.28437042	89.15	93.13		15.3500	53.2000	14.4500	10.0000
0.01456386	37.6022	27.8879		81.41446114	91.86198711	89.13	92.66		15.7600	54.1000	14.1100	10.1000
0.01492115	37.5163	26.1387		79.58307266	93.81654263	89.14	93.02		16.1600	54.8600	13.7700	10.2400
0.01310043	37.2246	24.1986		80.31878471	91.97723866	89.15	92.19		16.6000	55.5400	13.3500	10.2900
0.01222822	37.9538	24.6783		82.23457336	88.45453262	89.15	89.60		17.1100	56.2500	13.1600	10.2100
0.01219194	38.2962	23.9523		82.80990124	88.50927353	89.15	87.18		17.6900	56.9400	12.7700	10.0600
0.01238294	36.0286	20.2592		80.83708286	90.66228867	89.17	87.30		18.3800	57.7200	12.4900	9.9000
0.01435664	34.9798	18.1907		78.25388908	88.60168457	89.09	89.39		19.2000	58.6100	12.2200	9.7800
0.01363878	37.7445	19.4013		77.47378349	84.97519493	89.14	91.13		20.1200	59.5900	11.9900	9.7300
0.01360376	39.9536	22.3789		78.50148678	87.10627556	89.08	90.46		21.1500	60.7100	11.7800	9.7400
0.01364363	40.6368	22.499		79.77304459	92.55647659	89.04	87.75		22.2500	61.8700	11.5900	9.9000
0.01424008	41.085	22.1793		79.1292429	87.9598856	88.98	84.55		23.3800	63.2900	11.4400	10.3000
0.01439982	41.4062	21.8111		76.07555389	68.04103851	88.81	83.03		24.5000	64.8400	11.2900	11.0700
0.01372388	41.5799	21.0931		71.6632843	37.21311092	88.86	84.17		25.6600	66.5000	11.1700	12.3800
0.01360786	39.9595	18.5442		67.68081188	14.88251686	88.83	87.59		26.8000	68.2800	11.0600	14.4100
0.01388061	37.2544	15.1847		64.40806389	5.379414558	88.77	90.64		28.0500	70.1400	10.9300	17.3300
0.01354187	32.7853	11.2691		61.85297966	2.369427681	88.68	90.54		29.3300	72.0300	10.8900	21.0300
0.01220099	33.4645	11.0468		59.41827297	1.239037514	88.72	88.25		30.7100	73.9200	10.8400	25.2100

0.895	0.87		155	1	162	1		139	1	145	1			135	1	141	1
0.895	0.87		168	1	175	1		150	1	156	1			146	1	152	1
0.895	0.87		104	1	108	1		93	0	97	0			91	0	94	0
0.895	0.87		0	0	0	0		0	0	0	0			0	0	0	0
0.895	0.87		168	1	174	1		150	1	156	1			146	1	151	1
0.895	0.87		0	0	0	0		0	0	0	0			0	0	0	0
0.895	0.87		45	0	46	0		40	0	42	0			39	0	40	0
MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED	MEASURED
MACBETH TARGET	MACBETH TARGET	MACBETH T	MACBETH TARGET	MACBETH TARGET	MACBETH TARGET	MACBETH TARGET	MACBETH T	MACBETH TARGI	MACBETH TARGI	MACBETH TAR	MACBETH TA	MACBETH TARG	MACBETH T	MACBETH TARG	MACBETH TARG	MACBETH TARG	MACBETH TARG
Bluw Flower	**Bluish Green**	**Orange**	**Purplish Blue**	**Moderate Red**	**Purple**	**Yellow Green**	**Orange Ye**	**Blue**	**Green**	**Red**	**Yellow**	**Magenta**	**Cyan**	**White**	**Neutral 8**	**Neutral 6.5**	**Neutral 5**
reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect	reflect
30.8200	25.1400	5.9600	21.9400	16.5800	16.5300	7.1900	6.6200	13.8600	6.2500	5.6300	5.9400	25.8800	19.8000	39.6100	36.0700	27.3900	17.4500
37.3300	28.6400	5.9300	25.4800	16.8600	17.9500	7.2200	6.6500	15.6900	6.2600	5.5800	5.9800	30.8100	22.4200	53.5400	45.7400	31.6700	18.5300
41.4100	30.6800	5.9000	28.0400	16.6900	18.8600	7.2200	6.6100	17.3500	6.2900	5.5400	5.9600	33.9700	24.3500	67.8200	52.9000	33.9900	19.0400
43.4400	31.7500	5.8800	29.8800	16.3700	19.3500	7.2400	6.6200	18.8700	6.3000	5.5200	6.6800	35.8000	25.3300	78.7500	56.4000	34.8500	19.2200
44.3100	32.4100	5.8400	31.1300	16.0000	19.4500	7.2600	6.6000	20.0900	6.3600	5.4700	5.9500	36.6700	25.9100	84.6500	57.6100	35.1200	19.2800
44.6100	33.0200	5.8100	32.4600	15.6500	19.1700	7.3000	6.6000	21.5800	6.3800	5.4600	6.0200	36.6900	27.1900	87.1000	58.0400	35.2200	19.3700
44.6500	33.6900	5.8000	34.1100	15.4200	18.6300	7.3800	6.6000	23.7000	6.4700	4.5700	6.1000	35.9900	28.1300	88.1200	58.2400	35.3600	19.4800
44.4700	34.4300	5.8000	35.5500	15.2900	17.8300	7.5100	6.6400	25.8400	6.5600	6.5400	6.2200	34.8300	29.4900	88.5700	58.4500	35.5100	19.6000
44.1400	35.1800	5.8000	37.1600	15.2300	16.9000	7.6600	6.6700	28.5700	6.6700	5.4000	6.3800	33.4000	31.3100	88.8800	58.5700	35.6500	19.7400
43.7000	36.0900	5.8000	38.7400	15.1200	15.9000	7.8800	6.7500	31.7900	6.8500	5.4000	6.6000	31.8100	33.0500	89.1400	58.6900	35.7400	19.8200
43.1300	37.4000	5.8300	39.5000	14.9900	14.8600	8.2000	6.8700	34.1400	7.1100	5.4000	6.9000	30.1200	34.7800	89.3600	58.7200	35.7700	19.8500
42.4500	38.9400	5.8500	39.3200	14.8300	13.7900	8.5800	6.9900	34.9500	7.4300	5.4000	7.2700	28.3700	36.4200	89.5600	58.6700	35.7000	19.8000
41.8100	40.9900	5.8500	38.4000	14.6700	12.6900	9.0600	7.1500	34.1700	7.8500	5.3700	7.7500	26.7200	38.3000	89.6800	58.5300	35.5800	19.7100
41.0500	43.7000	5.8700	36.9700	14.5400	11.6600	9.7000	7.3500	32.1700	8.4000	5.3200	8.3400	25.1300	40.4000	89.7300	58.3600	35.4000	19.6000
40.1300	47.0500	5.9100	35.2600	14.3800	10.7300	10.5700	7.6400	29.1700	9.2100	5.2800	9.1700	23.6000	42.2800	89.7600	58.2200	35.2900	19.5200
39.0500	50.7400	5.9700	33.1400	14.1600	9.9100	11.7400	8.0300	25.4800	10.3800	5.2500	10.2500	22.1000	43.6100	89.8000	58.1200	35.1700	19.4300
37.8000	54.3000	6.0300	30.5300	13.7600	9.2200	13.2500	8.5200	21.5800	12.0100	5.2100	11.6600	20.5600	44.4100	89.7600	57.9800	35.0600	19.4000
36.8100	57.3200	6.1200	27.5000	13.2800	8.6200	15.2700	9.1600	17.7900	14.2400	5.2100	13.5800	19.1100	44.7100	89.8800	57.9500	35.0500	19.3900
35.8600	59.2200	6.2100	24.4300	12.7600	8.0400	17.8700	9.9000	14.4700	16.9900	5.2000	16.0400	17.8000	44.3300	89.8900	57.9400	35.0200	19.4000
34.8600	60.1200	6.3200	21.8300	12.3700	7.5100	21.1400	10.6500	11.8800	20.0000	5.1900	19.1000	16.7100	43.3600	89.8500	57.9200	34.9900	19.3800
33.8200	60.3200	6.4300	19.7400	12.1000	7.0800	25.1500	11.4200	9.9300	22.9900	5.1500	22.9200	15.8200	41.9600	89.7100	57.8400	34.9300	19.3500
32.6500	60.1400	6.6000	18.0400	11.9200	6.7500	30.2000	12.3600	8.4600	25.9300	5.1500	27.7500	15.0500	40.1700	89.5600	57.7900	34.8700	19.3300
31.1600	59.8100	6.9300	16.4600	11.7000	6.5400	36.3300	13.6400	7.3700	28.8400	5.1300	33.8600	14.3000	38.0500	89.4900	57.7900	34.8600	19.3500
29.2200	59.2000	7.4400	14.9800	11.3900	6.3900	42.7800	15.3900	6.5700	31.4400	5.1500	40.3200	13.4300	35.6500	89.3400	57.8100	34.8800	19.3500
26.9400	58.3400	8.2600	13.5700	11.0300	6.2300	48.4600	17.8200	6.0000	33.3100	5.1400	46.2000	12.4500	32.9800	89.1700	57.7800	34.8900	19.3900
24.7300	57.2000	9.4400	12.4000	10.7500	6.0600	52.6800	21.1300	5.6000	33.9500	5.1500	50.8500	11.5400	30.2500	89.0300	57.7900	34.8900	19.4000
22.9600	55.8400	11.1800	11.5600	10.6500	5.8700	55.2700	25.4100	5.3000	33.5000	5.1500	54.2300	10.8600	27.5700	88.9000	57.7800	34.8600	19.4000
21.6700	54.2400	13.5600	10.9800	10.7000	5.7400	56.5500	30.4500	5.0900	32.5400	5.1600	56.6400	10.5000	24.9700	88.7100	57.7200	34.8500	19.4000
20.8300	52.3600	16.6400	10.5600	10.8500	5.6800	56.8400	35.8700	4.9100	31.6600	5.1900	58.4400	10.4600	22.5000	88.5400	57.6900	34.8600	19.3900
20.4900	50.2400	20.2400	10.2200	11.0900	5.6500	56.4700	40.9600	4.7900	30.8600	5.2400	59.8700	10.6500	20.1800	88.2600	57.6400	34.8500	19.4000
20.4500	47.9300	24.2100	9.8500	11.3900	5.7000	55.5700	45.3400	4.6800	29.7300	5.3000	61.0400	10.8900	17.9500	87.8900	57.5800	34.8700	19.4000
20.3400	45.4800	28.3900	9.4200	11.5800	5.7600	54.3700	48.9100	4.5700	28.0600	5.3700	62.2100	10.9500	15.9100	87.4200	57.5200	34.8700	19.3900
19.6700	43.0300	32.7800	8.9800	11.5400	5.8300	52.9400	51.7100	4.5100	26.0400	5.4900	63.5100	10.9100	14.1400	86.9600	57.4700	34.9300	19.4500
19.1100	40.6400	37.1800	8.6100	11.3900	5.8500	51.3700	54.0500	4.4500	24.1200	5.6600	64.7000	10.9500	12.6700	86.4700	57.4200	35.0200	19.4800
18.8800	38.4100	41.3200	8.4400	11.5000	5.8000	49.7100	55.9400	4.4000	22.6400	5.9400	65.7700	11.3100	11.5500	86.2800	57.4000	35.1300	19.5500
19.0400	36.2600	44.9400	8.3700	12.4500	5.7200	47.9500	57.5000	4.3900	21.4700	6.3700	66.7800	12.1400	10.6900	86.4500	57.3400	35.2200	19.5800
19.5400	34.1600	47.9700	8.4200	14.8700	5.6300	46.1200	58.8600	4.3500	20.3700	7.0700	67.6500	13.4500	10.0200	86.9300	57.2800	35.3100	19.6500
20.2800	32.0800	50.4200	8.5100	19.1800	5.6000	44.1600	59.9900	4.3500	19.1000	8.1000	68.4400	15.2600	9.5200	87.4600	57.2100	35.3400	19.6500
21.0300	29.9600	52.4000	8.6200	25.1400	5.6600	42.0400	60.9500	4.3500	17.5500	9.7200	69.0700	17.5200	9.1000	87.7000	57.0700	35.3100	19.6500
21.6800	27.9100	54.0200	8.7200	31.9700	5.8500	39.8900	61.8700	4.3500	15.8700	12.3200	69.7100	20.4500	8.7400	87.8100	56.9800	35.2900	19.6300
22.2500	26.0500	55.3300	8.7300	38.6600	6.1900	37.8300	62.5900	4.3100	14.1900	16.4100	70.2500	24.2300	8.4000	87.7800	56.8800	35.2400	19.5800
22.8600	24.5500	56.4600	8.6700	44.4400	6.7500	36.0800	63.2500	4.3300	12.7500	22.4800	70.6100	29.2400	8.1500	87.6700	56.7900	35.1700	19.5300
23.4000	23.4000	57.4200	8.5800	48.9600	7.5300	34.7500	63.8500	4.3300	11.6000	30.0700	71.1000	35.5900	7.9600	87.6800	56.6400	35.0500	19.4500
23.4800	22.6300	58.2800	8.4900	52.0900	8.5300	33.8000	64.3300	4.3500	10.7200	38.2300	71.7700	42.9000	7.8500	87.7100	56.5300	34.9400	19.3600
23.2200	22.0900	59.0300	8.4500	54.1700	9.5800	33.1900	64.8300	4.3500	10.1200	45.8000	71.9800	50.4200	7.8000	87.8300	56.4100	34.8500	19.2900
23.0800	21.7400	59.7400	8.5000	55.5100	10.6200	32.7700	65.3100	4.3800	9.6500	52.1900	72.3300	57.4300	7.7500	88.0000	56.2900	34.7200	19.2100
23.3900	21.4700	60.3800	8.6700	56.3000	11.5900	32.5500	65.7700	4.4000	9.3100	57.2200	72.6500	63.3500	7.7500	88.2300	56.1800	34.6000	19.1500
24.1400	21.2300	60.9600	8.9900	56.7900	12.4500	32.2700	66.2100	4.4200	9.0000	61.0300	72.9900	68.1300	7.7500	88.5000	56.0500	34.4900	19.0500
25.4700	21.0300	61.5200	9.4000	57.0300	13.2600	32.0900	66.6000	4.4400	8.7500	63.8500	73.0900	71.7900	7.7500	88.7400	55.9100	34.3700	18.9900
27.6000	20.8400	62.0700	9.9200	57.2200	14.0500	31.9200	66.9900	4.4500	8.5000	65.9400	73.5100	74.6400	7.8100	88.9700	55.8200	34.2600	18.9300
30.5800	20.7800	62.6100	10.4900	57.3500	14.8200	31.8800	67.4200	4.5000	8.2700	67.5600	73.8800	76.8300	7.8700	89.1400	55.7100	34.1700	18.8400
34.1000	20.8200	63.1100	11.0900	57.4200	15.6100	30.9300	67.8100	4.5000	8.1300	68.7800	74.3900	78.6000	7.9500	89.3300	55.5900	34.0300	18.7600
38.0600	21.0500	63.6100	11.5900	57.4200	16.4400	32.0900	68.1500	4.5400	8.0000	69.6100	74.5900	79.9400	8.0600	89.4000	55.4800	33.9300	18.7000
42.0800	21.4700	63.9800	11.9100	57.3900	17.3400	32.8600	68.4500	4.5500	7.9300	70.0700	74.8400	80.9500	8.1400	89.2700	55.3200	33.8000	18.6000
45.7700	21.9700	64.4000	12.0300	57.3900	18.3000	33.5900	68.8000	4.5700	7.9200	70.1800	75.1800	81.6900	8.1500	89.1000	55.2500	33.7100	18.5500
48.8300	22.5300	64.7300	11.8900	57.3800	19.3900	34.4300	69.0800	4.6000	7.9400	70.1600	75.4800	82.2100	8.1300	88.9600	55.1700	33.6200	18.4700
51.1600	23.0800	65.1100	11.5800	57.3400	20.5700	35.2600	69.3300	4.6300	7.9800	70.2600	75.7600	82.6900	8.0700	88.8800	55.0600	33.5100	18.4100
52.8800	23.5800	65.4600	11.2500	57.3300	21.8700	36.0500	69.6100	4.6600	8.0800	70.4600	75.9800	83.0900	8.0100	88.8500	54.9500	33.4100	18.3400
54.0400	24.0600	65.9200	11.0100	57.2900	23.2600	36.7700	69.9300	4.7200	8.1900	70.7400	76.0300	83.3300	7.9400	88.8900	54.8400	33.2900	18.2900
54.8100	24.4400	66.3400	10.9100	57.3100	24.6900	37.3900	70.2800	4.7800	8.3500	71.2300	76.5300	83.5800	7.8400	88.8900	54.7200	33.2100	18.2200
55.2400	24.7300	66.7500	10.9300	57.2500	26.1800	37.8600	70.6800	4.8700	8.5600	71.6900	76.7600	83.7900	7.7600	88.9400	54.6200	33.1000	18.1500

		0.77465338	1.11041295	1.27625616	-1.36154422	-0.75623449	3.49056061	0.80793908	1.15812573	1.33109499		-1.42004774	-0.78872876	3.64054479
		0.83773398	1.20083469	1.38018265	-1.47241577	-0.81781522	3.77479954	0.87310749	1.25154021	1.43846117		-1.53458886	-0.85234766	3.9341913
		0.52101706	0.74684253	0.85838551	-0.91574863	-0.50862887	2.34768437	0.54202661	0.77695829	0.89299914		-0.95267538	-0.52913887	2.44235265
		0	0	0	0	0	0	0	0	0		0	0	0
		0.83817676	1.20146939	1.38091214	-1.47319402	-0.81824748	3.7767947	0.86962208	1.24654412	1.43271891		-1.52846286	-0.84894513	3.91848621
		0	0	0	0	0	0	0	0	0		0	0	0
		0.22400258	0.32109246	0.3690485	-0.39371082	-0.21867648	1.00934766	0.23207589	0.33266501	0.38234944		-0.40790061	-0.22655784	1.04572572
										0				
										0				
MEASURED	MEASURED	MEASURED	MEASURED	MEASURED		for lab test	for lab test	for lab test	for lab test	#VALUE!				
MACBETH TARG	MACBETH TARGE	WHEAT	WHEAT	WHEAT		Light Source	Light Source	Light Source		#VALUE!				
Neutral 3.5	**Black**	WHEAT-GRN	WHEAT-NEW	WHEAT-NORM		BB-5800	BB-6500	D65	LAB-TRANS	#VALUE!				
reflect	reflect	reflect	reflect	reflect		(Watts/m^2*un	(Watts/m^2*un	(Watts/m^2*un	(%)	#VALUE!				
9.2900	3.8600	6.000	5.000	4.000					100	33.045065				
9.3300	3.8600	6.000	5.100	4.200					100	35.090261				
9.5300	3.8500	6.000	5.200	4.300					100	36.056048				
9.4500	3.8500	6.000	5.300	4.500					100	36.396914				
9.6100	3.8500	6.000	5.400	4.600					100	36.510536				
9.5500	3.8500	6.100	5.500	4.700					100	36.680969				
9.5900	3.8200	6.100	5.600	4.800					100	36.889276				
9.6500	3.8000	6.100	5.600	4.900					100	37.11652				
9.6400	3.8000	6.000	5.600	5.000					100	37.381638				
9.6400	3.8100	6.000	5.600	5.000					100	37.533134				
9.7300	3.8500	6.000	5.500	5.000					100	37.589945				
9.6800	3.8400	6.000	5.400	5.000					100	37.49526				
9.5900	3.8100	5.900	5.300	4.900					100	37.324827				
9.5600	3.7900	5.900	5.100	4.800					100	37.11652				
9.4800	3.7600	5.900	5.000	4.700					100	36.965024				
9.4400	3.7500	5.800	4.900	4.700					100	36.794591				
9.4000	3.7600	5.800	4.800	4.600					100	36.73778				
9.4000	3.7700	5.800	4.800	4.600					100	36.718843				
9.4000	3.8000	5.900	4.800	4.700					100	36.73778				
9.3900	3.7700	5.900	4.800	4.800					100	36.699906				
9.3500	3.7500	6.000	5.000	5.000					100	36.643095				
9.3300	3.7300	6.100	5.300	5.300					100	36.605221				
9.3400	3.7000	6.300	5.600	5.600					100	36.643095				
9.3500	3.7000	6.400	5.900	6.000					100	36.643095				
9.3300	3.7000	6.600	6.300	6.400					100	36.718843				
9.3500	3.7000	6.700	6.800	6.800					100	36.73778				
9.3400	3.7000	6.900	7.100	7.100					100	36.73778				
9.3400	3.7000	7.000	7.500	7.400					100	36.73778				
9.3400	3.7000	7.000	7.700	7.500					100	36.718843				
9.3400	3.7000	7.000	7.900	7.500					100	36.73778				
9.3300	3.7000	7.000	8.000	7.500					100	36.73778				
9.3400	3.6900	6.900	7.900	7.500					100	36.718843				
9.4100	3.7000	6.700	7.800	7.400					100	36.832465				
9.4100	3.7000	6.500	7.500	7.400					100	36.889276				
9.4400	3.7000	6.200	7.200	7.300					100	37.021835				
9.4700	3.6900	6.000	6.800	7.300					100	37.078646				
9.4900	3.6700	5.700	6.400	7.200					100	37.211205				
9.5000	3.6900	5.500	6.000	7.200					100	37.211205				
9.5000	3.6800	5.300	5.600	7.100					100	37.211205				
9.4900	3.6800	5.100	5.300	7.100					100	37.173331				
9.4500	3.6700	5.000	5.000	7.000					100	37.078646				
9.4400	3.7000	5.000	4.800	6.900					100	36.983961				
9.4000	3.6900	5.000	4.700	6.800					100	36.832465				
9.3800	3.7000	5.100	4.700	6.800					100	36.662032				
9.2600	3.7000	5.200	4.800	6.600					100	36.529473				
9.2900	3.7000	5.400	5.000	6.500					100	36.377977				
9.2400	3.7000	5.500	5.200	6.400					100	36.264355				
9.2000	3.7000	5.700	5.500	6.200					100	36.074985				
9.1600	3.7100	5.800	5.900	6.000					100	35.961363				
9.1200	3.7200	5.900	6.400	5.800					100	35.847741				
9.1000	3.7500	6.000	7.000	5.500					100	35.677308				
9.0400	3.7500	6.000	7.600	5.200					100	35.525812				
9.0900	3.7500	6.000	8.300	4.900					100	35.41219				
9.0300	3.7500	6.100	9.100	4.600					100	35.22282				
8.9900	3.7800	6.200	9.900	4.400					100	35.128135				
8.9600	3.7900	6.500	11.000	4.300					100	34.976639				
8.9300	3.8000	6.900	12.000	4.400					100	34.863017				
8.9100	3.8000	7.500	12.000	4.600					100	34.730458				
8.9000	3.8000	8.400	13.000	5.000					100	34.635773				
8.8500	3.8000	9.500	14.000	5.600					100	34.503214				
8.8200	3.8100	11.000	15.000	6.500					100	34.370655				

705	1376.091299	54.2639822	0.006514259	77.7966708	6.618919	1372.66	2.75098	0.004216593	20.7924	7.15937	1372.66	10.4535
710	1358.760891	54.993245	0.005800058	78.20767165	6.486348	1344.64	2.90676	0.003710572	21.8744	7.44872	1344.64	11.0902
715	1310.483828	54.1369319	0.004924318	77.750051	6.024314	1326.17	2.69244	0.003110921	20.3333	6.50893	1326.17	10.3124
720	1298.131836	46.70186635	0.008287265	73.479563	5.169381	1288.02	1.46054	0.005354783	11.9871	3.10228	1288.02	5.62042
725	1308.823058	48.3414516	0.008581391	74.46464895	5.269535	1305.68	1.56623	0.00552152	12.7168	3.37066	1305.68	6.04974
730	1289.078343	51.22789145	0.007937358	76.1275381	5.328941	1285.97	1.99324	0.005082669	14.912	4.12209	1285.97	7.73304
735	1282.704548	55.28528395	0.007647844	78.4056336	5.552834	1270.59	2.78549	0.004865798	20.2836	6.00559	1270.59	10.8511
740	1247.168477	56.646505	0.007568225	79.1498631	5.423266	1229.27	3.35881	0.004783296	23.6773	7.33318	1229.27	13.1422
745	1230.483521	57.42870865	0.007083758	79.5783311	5.314680	1243.96	3.66932	0.004452042	25.2649	8.18578	1243.96	14.4198
750	1210.575867	57.7640146	0.008050138	79.7645837	5.172945	1222.27	3.75254	0.005067558	25.5113	8.10858	1222.27	14.813
755	1229.677776	58.05154145	0.008064294	79.9249351	5.157279	1205.4	3.59314	0.005054721	22.1942	6.82749	1205.4	14.2436
760	1211.819252	58.32761225	0.007895086	80.07903995	5.020394	1205.51	2.42996	0.004927612	16.3471	4.41274	1205.51	9.68394
765	1190.903805	58.59603285	0.008204333	80.22874595	4.852463	1169.17	3.82303	0.005098979	25.4885	7.48758	1169.17	15.3022
770	1172.114159	58.85822475	0.007745095	80.37478625	4.722187	1157.14	3.91394	0.0047933	25.9509	7.50797	1157.14	15.7404
775	1127.071854	59.1197938	0.007745095	80.52031395	4.461673	1157.14	3.91394	0.0047933	25.9509	7.50797	1157.14	15.7404
780	1145.538517	59.3764424	0.008050615	80.66318035	4.470394	1145.57	3.93952	0.004961631	26.0199	7.35959	1145.57	15.92
785	1148.8408	59.54253075	0.008234668	80.758211	4.429852	1141.05	3.50588	0.005047501	23.5125	6.06579	1141.05	14.2358
790	1135.946145	59.2721522	0.008343895	80.62533435	4.277823	1101.95	3.56687	0.005086921	23.7959	5.90486	1101.95	14.5566
795	1083.731723	59.59531965	0.007427061	80.8045477	4.034330	1101.95	3.56687	0.005086921	23.7959	5.90486	1107.24	13.7825
800	1090.53775	59.8304927	0.007427061	80.93492985	3.999680	1107.24	3.36007	0.004503881	22.6535	5.34094	1107.24	13.7825
805	1066.231047	60.24545135	0.008011282	81.15911185	3.872996	1080.08	3.61886	0.00483256	24.1455	5.6971	1080.08	14.9207
810	1068.348147	60.14277335	0.008054364	81.1144233	3.810086	1077.5	2.65115	0.004833298	17.0019	3.61691	1077.5	10.9847
815	1076.35474	56.2300354	0.007703524	79.041633	3.552723	1044.57	2.5132	0.004598856	17.0835	3.34676	1.04E+03	10.4734
820	1027.577838	55.87137935	0.007703524	78.88599335	3.316206	1044.57	2.5132	0.004598856	17.0835	3.34676	1.04E+03	10.4734
825	1038.665451	57.0500076	0.007916368	79.5198262	3.364277	1043.41	2.67893	0.004701823	18.3569	3.65403	1.04E+03	11.2223
830	1031.994465	58.0738813	0.006447885	80.0571382	3.338379	1013.73	3.37609	0.003810175	21.5468	4.45075	1.01E+03	14.2249
835	1012.501056	60.6677443	0.006447885	81.4173609	3.355882	1008.31	3.87881	0.004758961	24.7414	5.22697	1.01E+03	16.4328
840	1006.151304	61.7629081	0.008093862	81.99347555	3.330219	1008.31	3.87881	0.004758961	24.7414	5.22697	1.01E+03	16.4328
845	997.0797045	62.38684055	0.008003641	82.32040405	3.276919	952.314	4.15342	0.004682592	26.2403	5.39242	9.52E+02	17.6953
850	902.3454394	62.6583546	0.005576934	82.4646354	2.906327	906.241	4.28287	0.003246728	26.7196	5.24286	9.06E+02	18.3536
855	750.9360973	63.00286355	0.005576934	82.645458	2.448407	906.241	4.28287	0.003246728	26.7196	5.24286	9.06E+02	18.3536
860	968.0076041	63.36696145	0.007798175	82.83726275	3.068963	967.81	4.46675	0.004517881	27.3999	5.70903	9.68E+02	19.2541
865	955.512249	63.6261523	0.007518328	82.97601045	2.966765	954.63	4.52441	0.004334659	27.5486	5.60796	9.55E+02	19.6197
870	939.2761831	63.85358575	0.007518328	83.09876025	2.906340	954.63	4.52441	0.004334659	27.5486	5.60796	9.55E+02	19.6197
875	924.6537796	64.0629202	0.007510409	83.2130611	2.820978	935.938	4.52304	0.004309275	27.5012	5.42772	9.36E+02	19.7334
880	938.7087087	64.2203301	0.006712075	83.3022416	2.827747	923.687	4.42821	0.003832961	26.9223	5.06562	9.24E+02	19.4396
885	931.9613074	64.2835468	0.006712075	83.3474517	2.757584	923.687	4.42821	0.003832961	26.9223	5.06562	9.24E+02	19.4396
890	922.78114	63.8540655	0.007820072	83.14956125	2.676192	904.78	3.58632	0.004444541	21.0476	3.54717	9.05E+02	15.835
895	908.7542137	58.1160873	0.007223434	80.1781535	2.384232	876.771	1.92681	0.004086188	13.2454	1.71682	8.77E+02	8.57339
900	896.2156296	47.45394735	0.007223434	74.20465055	1.913408	876.771	1.92681	0.004086188	13.2454	1.71682	8.77E+02	8.57339
905	902.2107024	52.4522662	0.006990214	77.18827725	2.075451	838.566	1.87085	0.003936106	12.3665	1.53636	8.39E+02	8.37326
910	862.1362468	50.11440215	0.006990214	75.8243412	1.883659	838.566	1.87085	0.003936106	12.3665	1.53636	8.39E+02	8.37326
915	881.4028164	51.7136514	0.00696177	76.716578	1.946730	829.323	2.35508	0.003901927	14.6356	1.83528	8.29E+02	10.6168
920	865.94112	56.58044815	0.007638964	79.48746385	2.031949	803.252	1.91865	0.004261747	11.9105	1.38961	8.03E+02	8.69568
925	829.726019	54.51864005	0.007638964	78.42707335	1.858119	803.252	1.91865	0.004261747	11.9105	1.38961	8.03E+02	8.69568
930	839.3253347	23.3123839	0.007553134	56.355229	0.924876	783.588	0.043123	0.004194792	0.578057	0.0693824	7.84E+02	0.197525
935	834.9472333	4.023808985	0.007553134	28.76042275	0.299666	783.588	0.043123	0.004194792	0.578057	0.0693824	7.84E+02	0.197525
940	821.5615165	9.87044573	0.007408844	40.9428805	0.461704	770.602	0.0719309	0.00409604	1.59321	0.152867	7.71E+02	0.330867
945	810.6509695	8.83114524	0.007408844	39.0466988	0.429959	770.602	0.0719309	0.00409604	1.59321	0.152867	7.71E+02	0.330867
950	809.8953518	14.17649535	0.007108455	46.72129005	0.579446	740.985	0.302585	0.003912249	2.73092	0.27841	7.41E+02	1.40362
955	784.991225	24.7709684	0.006623024	58.27285945	0.836520	742.662	1.12649	0.003628807	7.32795	0.731798	7.43E+02	5.25986
960	795.2795486	39.1705662	0.006623024	68.959713	1.204311	742.662	1.12649	0.003628807	7.32795	0.731798	7.43E+02	5.25986
965	776.3217595	49.1950735	0.007339466	75.35231115	1.395876	739.04	2.46444	0.004003607	15.8153	1.64032	7.39E+02	11.5825
970	770.4641035	58.03231595	0.007339466	80.32804135	1.583437	739.04	2.46444	0.004003607	15.8153	1.64032	7.39E+02	11.5825
975	753.1152558	58.4601641	0.00707599	80.5194229	1.535682	739.49	3.47275	0.003842745	20.0039	2.26934	7.39E+02	16.461
980	751.6964223	62.7574921	0.00707599	82.72274435	1.613753	739.49	3.47275	0.003842745	20.0039	2.26934	7.39E+02	16.461
985	744.0839836	67.01669695	0.00683209	84.84671115	1.669551	736.418	4.93093	0.003694059	27.6681	3.49661	7.36E+02	23.5459
990	731.48558	68.92232595	0.00683209	85.777992	1.662931	736.418	4.93093	0.003694059	27.6681	3.49661	7.36E+02	23.5459
995	731.2219005	69.5274979	0.006762118	86.0715747	1.646259	721.47	5.08678	0.003640199	28.2721	3.47483	7.36E+02	23.5459
1000	724.9275	69.75542605	0.006762118	86.1840606	1.609839	721.47	5.08678	0.003640199	28.2721	3.47483	7.21E+02	24.4804

0.01057812	36.3111	12.6603		57.16547966	0.799226761	88.50	87.14		32.1000	75.7400	10.7800	29.2400
0.00937674	38.2644	13.4844		55.05619049	0.609517097	88.43	88.44		33.5500	77.4800	10.7400	32.6400
0.00791317	35.6274	11.2732		53.86133194	0.537085533	88.50	87.85		35.2800	79.0700	10.7000	35.1200
0.01332684	21.0415	4.08685		54.25887108	0.488615036	88.33	79.06		37.3900	80.3700	10.7100	36.7800
0.01376297	22.3596	4.47042		56.86705112	0.38485527	88.26	65.36		39.7500	81.5700	10.7000	37.8300
0.01267848	26.2662	5.94477		61.03525162	0.249457359	88.07	54.22		42.2400	82.5800	10.7000	38.5800
0.01215805	35.7907	10.2125		64.26401138	0.141239166	88.05	48.31		44.7100	83.3800	10.7000	39.0800
0.01198896	41.855	13.6529		63.8584137	0.078320503	87.86	44.25		47.1400	84.0500	10.7100	39.4800
0.0111859	44.7433	15.8476		60.24274826	0.050354004	87.88	36.26		49.4000	84.6800	10.7600	39.8700
0.01270642	45.264	15.738		57.41860867	0.040435791	87.87	24.59		51.5600	85.0400	10.8000	40.1900
0.0126883	39.4498	12.8203		56.46102428	0.035119057	87.69	15.24		53.3800	85.3900	10.8000	40.5100
0.01238507	29.1166	6.9548		52.9178381	0.050139427	87.56	10.04		54.7900	85.7400	10.8700	40.8700
0.01282838	45.4856	14.2788		43.61031055	0.073027611	87.43	7.53		55.7100	85.9300	10.9100	41.1500
0.01207098	46.4026	14.4238		36.30588055	0.069308281	87.30	6.48		56.1200	86.1100	10.9600	41.4800
0.01207098	46.4026	14.4238		40.08622169	0.068664551	87.36	6.31		56.3100	86.2200	11.0300	41.8000
0.01250683	46.6197	14.0812		30.06985188	0.047445297	87.19	6.64		56.2600	86.4000	11.1100	42.1300
0.01274073	42.2129	10.8121		4.770207405	0.009942055	87.01	6.55		56.0400	86.5100	11.1900	42.4900
0.01285751	42.8108	10.6227		0.850582123	-0.013279915	87.12	5.31		55.6500	86.5200	11.2500	42.8200
0.01139894	40.8419	9.2381		0.209999084	-0.002813339	86.98	3.64		55.1600	86.5400	11.3400	43.1000
0.01139894	40.8419	9.2381		0.053858757	-0.016403198	86.78	2.44		54.7300	86.5900	11.4400	43.4500
0.01224662	43.6253	10.1047		0.00333786	0.004959106	86.65	1.73		54.2200	86.6500	11.5600	43.7400
0.01226411	30.7838	5.31015		0	-0.019955635	86.34	1.39		53.7600	86.7500	11.6200	44.1000
0.01168376	31.0025	4.96606		0	0.000739098	86.67	1.27		53.2500	86.8400	11.7500	44.4700
0.01168376	31.0025	4.96606		0	0.069284439	86.51	1.31		52.8100	86.8200	11.8400	44.7700
0.01196017	33.3876	5.53534		0	0.172710419	86.31	1.55		52.5500	86.4900	11.9800	45.0800
0.00970379	39.2812	7.23277		0	0.459074974	86.08	2.04		52.1300	86.7200	12.0400	45.3900
0.01213456	45.2096	9.10912		0	0.279140472	86.06	2.85		51.8900	86.9400	12.1600	45.6800
0.01213456	45.2096	9.10912		0	0.044441223	85.91	3.44		51.7000	86.8900	12.2300	45.8800
0.01195366	48.0618	9.70061		0	-0.009274483	86.27	2.72		51.5200	86.8100	12.3000	46.0600
0.0082977	49.0582	9.46073		0	-0.16951561	86.01	1.67		51.3900	86.8700	12.1800	46.2500
0.0082977	49.0582	9.46073		0	-0.162434578	85.72	0.73		51.3900	86.4900	12.0500	46.4600
0.01155953	50.4304	10.329		0.026607513	-0.333142281	85.56	1.01		51.1000	86.9900	11.9000	46.1000
0.01110309	50.8309	10.0964		0.021028519	1.78976059	85.76	1.41		50.5300	86.6200	11.3600	46.3300
0.01110309	50.8309	10.0964		0.123429298	-0.428986549	85.61	0.88		50.9700	87.0200	11.7600	46.2100
0.01104999	50.8723	9.69179		0	0.85504055	85.53	1.53		51.2300	86.8800	12.1600	46.7000
0.00983925	49.9301	8.83625		0.064563751	0.823140144	85.46	1.17		51.3800	87.1100	12.3700	46.9900
0.00983925	49.9301	8.83625		0.003027916	0.134921074	85.65	2.88		52.2200	86.9400	12.6900	47.1100
0.01142126	39.1339	5.41152		0.051808357	3.08535099	85.67	2.91		52.4000	87.0200	12.9000	47.4500
0.01051148	24.6988	1.98186		0.114345551	0.687146187	85.40	4.75		53.1600	87.3000	13.3700	47.5300
0.01051148	24.6988	1.98186		0.129055977	2.501749992	85.61	5.26		53.6700	87.0800	13.8100	47.6600
0.01013584	23.1197	1.69856		0		85.14	3.04		54.2800	87.2600	14.1000	47.9400
0.01013584	23.1197	1.69856		0.13666153		85.02	1.97		54.9500	87.2600	14.4600	48.0500
0.01005806	27.4413	2.17575		0.137066841		85.31	2.31		55.7300	87.2400	14.7500	48.1600
0.01099669	22.3885	1.40905		0.051164627		84.97	0.46		56.5500	87.3500	15.0800	48.3000
0.01099669	22.3885	1.40905		0.07724762		85.27	2.47		57.3800	87.2900	15.3400	48.4400
0.01083475	1.09027	0.0408476		0.345921516		84.88	-0.49		58.2000	87.5100	15.6300	48.6800
0.01083475	1.09027	0.0408476		0.016880035		85.08	0.95		59.1500	87.4900	15.9800	48.7300
0.01058991	3.01269	0.0787502		0.239419937		85.05	0.41		60.0600	87.4900	16.3700	48.8900
0.01058991	3.01269	0.0787502		0		84.92	0.95		61.0600	87.5500	16.7600	48.9600
0.01012488	5.18036	0.150957		0.110292435		85.36	1.53		62.0200	87.5700	17.1600	49.0600
0.00940024	13.9429	0.539177		0		85.12	1.68		62.9500	87.6300	17.5500	49.1700
0.00940024	13.9429	0.539177		0.087165833		84.83	3.40		64.0100	87.6400	17.9700	49.2500
0.01038102	30.18	1.82415		0		84.84	2.64		64.8600	87.6900	18.4300	49.4000
0.01038102	30.18	1.82415		0.092840195		84.99	2.58		65.8600	87.6900	18.8600	49.4100
0.0099732	38.2997	2.88002		0.108408928		84.74	2.57		66.7300	87.6800	19.3600	49.5400
0.0099732	38.2997	2.88002		0.065588951		84.89	1.14		67.6200	87.7400	19.8800	49.6000
0.00959603	53.142	5.36086		0		84.69	0.63		68.4100	87.7100	20.4000	49.6300
0.00959603	53.142	5.36086		0.115776062		84.74	1.00		69.1200	87.7400	20.9200	49.6600
0.00959603	53.142	5.36086		0		84.64	1.38		69.8200	87.7200	21.4900	49.7100
0.00946491	54.4806	5.33153		0.037431717		84.53	0.60		70.4400	87.6900	22.0200	49.6900

55.5100	24.8100	67.1000	11.0600	57.2000	27.6700	38.1600	71.0200	4.9800	8.7600	72.2400	77.0600	83.9300	7.6800	89.0200	54.5200	33.0300	18.0800
55.6900	24.7100	67.4500	11.2900	57.0700	29.1500	38.2000	71.3900	5.1000	8.9500	72.8500	77.3100	84.0700	7.7000	89.1600	54.4200	32.9300	18.0300
55.8300	24.4400	67.7800	11.5800	57.1300	30.5200	38.0400	71.7300	5.2600	9.0400	73.3300	77.6100	84.3300	7.7800	89.3700	54.3600	32.8400	17.9800
55.8800	24.1400	68.1700	11.9400	57.1100	31.7500	37.7200	71.9700	5.4200	9.0800	73.8000	77.8100	84.7800	7.9300	89.4800	54.2400	32.7100	17.8900
55.9100	24.0000	68.4700	12.3400	57.0800	32.8800	37.6000	72.2700	5.6100	9.0900	74.2800	78.0700	85.2400	8.1700	89.6200	54.1200	32.6500	17.8200
55.9800	24.1400	68.8000	12.8800	57.0500	33.9100	37.8200	72.4900	5.8600	9.1700	74.7700	78.2900	85.7200	8.5000	89.8100	54.0400	32.5500	17.7600
55.9800	24.6500	69.1600	13.6900	57.0600	34.8100	38.4800	72.8000	6.1900	9.3200	75.3400	78.5200	86.4000	8.9700	90.1000	53.9100	32.4500	17.6900
56.0700	25.4600	69.4900	14.9200	57.0100	35.4700	39.5800	73.0500	6.6900	9.5700	75.9500	78.6700	86.9300	9.7000	90.3900	53.8200	32.3700	17.6300
56.0700	26.5900	69.7300	16.5900	56.9900	36.0900	40.9700	73.2800	7.4100	9.9100	76.6200	78.9300	87.4500	10.8100	90.7100	53.8000	32.2800	17.5800
56.0900	27.8200	70.0000	18.6900	56.9600	36.6200	42.4500	73.5000	8.3400	10.3100	77.3300	79.1500	87.9700	12.4200	90.9500	53.6900	32.1900	17.5000
56.1000	29.0500	70.3000	21.1600	56.9600	37.0400	43.9000	73.7100	9.5000	10.7500	77.8400	79.0700	88.3100	14.5000	91.2300	53.5500	32.0700	17.4400
56.1500	30.1200	70.5900	23.8500	57.0000	37.4300	45.1400	73.9400	10.8200	11.2100	78.4400	79.6000	88.6200	16.7600	91.4500	53.5100	31.9800	17.4000
56.2000	30.9300	70.8200	26.6900	56.9900	37.7600	46.0700	74.1800	12.2800	11.7000	78.9300	79.7800	88.8100	18.8300	91.6300	53.4300	31.9100	17.3400
56.1800	31.4300	71.0300	29.7300	56.9400	38.0400	46.6600	74.2800	13.8500	12.3000	79.3100	79.8600	88.8700	20.3400	91.7100	53.2900	31.8000	17.2600
56.1900	31.6600	71.2400	33.1700	57.0000	38.2600	47.0400	74.5000	15.6800	13.1100	79.7900	79.9300	88.9400	21.3800	91.8300	53.2000	31.7100	17.2000
56.2200	31.8300	71.4300	37.0900	57.0100	38.5500	47.3500	74.7200	17.7300	14.2500	80.2600	80.0900	89.0500	22.0800	91.9600	53.1000	31.6400	17.1300
56.2600	32.1300	71.6900	41.7300	56.9900	38.7700	47.7700	74.8900	20.1200	15.8000	80.7100	80.2400	89.0000	22.7200	92.0700	53.0400	31.5600	17.0600
56.3100	32.7200	71.9100	46.9200	57.1500	38.8800	48.4600	74.9900	22.7700	17.7400	81.0900	80.3900	89.0200	23.4200	92.1600	52.9600	31.4300	17.0300
56.2500	33.6700	72.0500	52.1000	57.1500	39.1100	49.4900	75.1600	25.5100	20.1800	81.4300	80.5200	88.9900	24.3500	92.1600	52.8500	31.3300	16.9700
56.3100	35.0500	72.2200	56.8800	57.1600	39.3300	50.8300	75.2400	27.9500	23.0400	81.8000	80.5600	88.9600	25.5400	92.2000	52.7800	31.2200	16.9000
56.3000	36.8100	72.4000	60.9300	57.1900	39.4700	52.2900	75.3700	30.1500	26.3100	82.1500	80.6900	88.9700	26.9700	92.2300	52.6700	31.1400	16.8700
56.3500	38.8300	72.6200	64.4000	57.2100	39.5900	53.8900	75.5700	32.0700	30.0100	82.5000	80.6800	89.0000	28.6000	92.3000	52.5800	31.0600	16.7900
56.3100	40.9900	72.7600	67.3000	57.2500	39.7500	55.4900	75.6100	33.7300	33.9600	82.7600	80.2900	89.0200	30.3900	92.2400	52.4900	30.9600	16.7400
56.3500	43.2900	72.8900	69.8000	57.2600	39.8900	56.9300	75.7700	35.2600	38.1800	83.0800	81.5800	89.0400	32.2000	92.1800	52.3900	30.9200	16.6700
56.4200	45.6400	73.1200	71.9400	57.3300	40.1200	58.3100	75.8400	36.6300	42.5600	83.4000	80.9200	89.0800	34.1300	92.3000	52.3100	30.8100	16.6000
56.3400	47.8900	73.1700	73.6900	57.3200	40.1600	59.4400	75.9700	37.8900	46.9300	83.6400	80.7400	88.9300	36.0000	92.2900	52.1600	30.6900	16.5300
56.3800	50.1800	73.4200	75.3300	57.4000	40.2700	60.5100	76.1300	39.0800	51.2900	83.9600	81.0200	89.1000	37.9400	92.2800	52.1500	30.5600	16.4900
56.4000	52.2700	73.5100	76.7200	57.4400	40.4200	61.3600	76.2000	40.1800	55.4800	84.2900	81.2400	89.0900	39.7500	92.3400	52.0300	30.4100	16.4100
56.2800	54.3200	73.5400	77.8400	57.4900	40.3300	61.9400	76.1900	41.2600	59.3500	84.5300	81.3000	88.9300	41.5200	91.9900	51.9100	30.3100	16.3400
56.2300	56.1700	73.7100	78.7800	57.3100	40.2500	62.4600	76.3000	42.2700	62.8900	84.6500	81.2600	89.0200	43.2300	92.1700	51.8200	30.1800	16.2300
56.1800	57.7700	73.5300	79.4300	57.2400	40.0300	62.5600	76.3100	43.1900	66.0600	85.0500	81.0700	88.8000	44.7700	92.0400	51.6800	30.0200	16.0900
56.0000	59.0100	73.8500	79.7500	56.8100	40.5000	63.4400	76.3400	43.3300	67.9700	85.4000	81.4200	88.9000	45.5100	92.1900	51.4000	29.4500	15.2500
55.9100	59.9500	73.5400	80.4600	56.7800	39.9400	63.8200	76.1500	44.3500	69.9600	84.9600	81.4200	88.8000	46.0300	91.9700	51.1100	29.1400	14.3400
55.8800	60.9500	73.6800	80.9700	56.7500	40.4200	64.0200	76.4600	44.8800	72.0800	85.6200	81.5900	88.9100	47.2700	92.0200	50.9000	28.7100	14.7600
55.8800	62.1300	74.0700	81.7600	56.6100	40.9400	64.9100	76.6900	46.2700	74.5500	85.6200	81.4000	88.6800	48.7900	92.1100	50.9000	28.8500	14.8700
55.9400	63.1900	74.2300	82.0600	57.0900	41.2400	65.1300	76.8500	47.2300	76.1600	86.1800	81.5400	88.9400	49.4900	91.9600	50.8200	29.0800	14.9200
56.0300	63.9700	74.4800	82.4700	56.8700	41.3900	65.2800	76.7700	48.1800	77.7000	86.1700	81.7300	88.6000	50.5000	91.8900	50.9500	28.8100	14.7500
56.1600	64.7700	74.3100	82.7600	57.1500	41.5300	65.6300	76.9600	48.9800	78.8400	86.2500	81.6600	88.7500	51.1200	91.8800	50.7100	28.9800	14.8800
56.2100	65.3100	74.5900	82.7300	57.1300	42.1300	65.7800	76.9800	50.1200	80.0600	86.6200	81.9100	88.6900	51.7500	91.9400	50.9500	29.0200	14.8700
56.3000	65.9900	74.7800	83.2100	57.2000	42.0200	66.0100	77.2600	51.0900	81.1700	86.5700	81.9800	88.7000	52.1500	91.8400	50.8000	29.0000	14.8900
56.2900	66.3200	74.7800	83.1400	57.2500	42.4800	66.1600	77.1800	51.9900	81.7800	86.6600	82.0400	88.8900	52.4500	91.8100	50.8200	28.9800	15.0700
56.3000	66.7500	75.0000	83.3500	57.1500	42.5900	66.3600	77.3600	52.8400	82.5600	86.8600	82.1700	88.6700	52.8100	91.8000	50.7000	28.9900	15.0900
56.3600	66.9900	75.0800	83.1300	57.3800	42.7900	66.4200	77.3900	53.7600	83.1500	86.8100	82.0500	88.6900	53.1800	91.7000	50.7400	28.9500	15.1000
56.2900	67.3400	75.2800	83.2400	57.2700	43.0000	66.4900	77.4500	54.6000	83.5700	86.9700	82.3100	88.6300	53.6100	91.7100	50.7500	28.8700	15.0200
56.3700	67.5300	75.3800	83.2000	57.2700	43.2500	66.6100	77.6000	55.4600	83.9800	86.9000	82.2800	88.5700	54.0000	91.6400	50.6200	28.9000	15.0100
56.3600	67.6600	75.5200	83.2100	57.2800	43.4200	66.6600	77.7300	56.4200	84.3600	87.1000	82.5400	88.6100	54.5500	91.7400	50.6500	28.8200	15.0100
56.4100	67.9900	75.7100	83.4800	57.3100	43.6200	66.8700	77.8600	57.4400	84.7400	87.2100	82.5800	88.4900	55.1300	91.7200	50.5600	28.7800	15.0500
56.4400	68.1600	75.8000	83.5300	57.3100	43.7700	66.9000	77.9000	58.4100	84.9800	87.2300	82.6300	88.5800	55.5400	91.6700	50.5400	28.7200	15.0300
56.4600	68.3600	75.9700	83.7500	57.2700	44.0000	67.0300	78.0500	59.3400	85.2300	87.3500	82.7700	88.5100	55.9900	91.7600	50.5100	28.6900	15.0100
56.4700	68.5100	76.1100	83.8200	57.3000	44.1000	67.1200	78.1700	60.3800	85.6300	87.3500	82.7400	88.5400	56.4100	91.7000	50.4600	28.6400	15.0200
56.4500	68.7200	76.1900	83.9200	57.3100	44.2800	67.1400	78.2200	61.3400	85.9200	87.3900	82.8900	88.4900	56.8100	91.7000	50.4100	28.5600	14.8900
56.5000	68.8900	76.3500	84.1000	57.3200	44.4500	67.2900	78.3200	62.3400	86.2000	87.4500	82.9300	88.5200	57.2000	91.7100	50.3400	28.5100	14.9200
56.4700	69.0200	76.4000	84.1300	57.3900	44.6500	67.3300	78.4200	63.2500	86.3200	87.4700	83.1100	88.5700	57.5900	91.6700	50.3300	28.5100	14.9400
56.5000	69.1400	76.4700	84.1500	57.3300	44.7900	67.4000	78.4800	64.1300	86.4500	87.4700	83.1500	88.5500	57.8800	91.6400	50.3000	28.4200	14.9100
56.5000	69.2700	76.6000	84.2600	57.4100	44.9100	67.4400	78.5500	65.0400	86.5700	87.4300	83.1800	88.5600	58.1100	91.5600	50.2400	28.3800	14.8700
56.4700	69.3700	76.6700	84.3100	57.3800	45.0800	67.4800	78.5600	65.8600	86.6500	87.4900	83.2500	88.5200	58.3100	91.5700	50.1800	28.3100	14.8200
56.4600	69.4600	76.7500	84.3300	57.4000	45.2600	67.5100	78.6200	66.6800	86.7400	87.4700	83.2600	88.4800	58.3800	91.4400	50.1000	28.2400	14.8100
56.4200	69.5200	76.8100	84.3100	57.4100	45.3200	67.5300	78.6600	67.4700	86.7600	87.4200	83.3000	88.4200	58.4900	91.3900	50.0500	28.1800	14.8000
56.3500	69.5900	76.8700	84.3500	57.4000	45.4400	67.5500	78.6800	68.2300	86.8000	87.4500	83.3200	88.3800	58.5000	91.3200	49.9900	28.1100	14.7700
56.3100	69.6500	76.9600	84.3500	57.4200	45.5900	67.6000	78.7600	68.9300	86.8100	87.3700	83.3600	88.2800	58.4900	91.3000	49.8900	28.0800	14.7400

8.8000	3.8000	13.000	16.000	7.700	100	34.238096
8.7600	3.8000	15.000	17.000	9.100	100	34.143411
8.7500	3.8100	17.000	17.000	11.000	100	34.048726
8.7100	3.8000	20.000	18.000	13.000	100	33.878293
8.7000	3.8200	23.000	19.000	15.000	100	33.745734
8.6600	3.8300	25.000	19.000	17.000	100	33.632112
8.6100	3.8500	28.000	20.000	19.000	100	33.499553
8.7000	3.8500	30.000	21.000	21.000	100	33.385931
8.6200	3.8600	32.000	21.000	23.000	100	33.291246
8.5900	3.8800	34.000	22.000	25.000	100	33.13975
8.5600	3.8600	35.000	23.000	27.000	100	33.026128
8.5200	3.8600	37.000	23.000	29.000	100	32.95038
8.5700	3.8900	37.000	24.000	30.000	100	32.836758
8.4800	3.9000	38.000	24.000	32.000	100	32.685262
8.4500	3.8800	38.000	25.000	33.000	100	32.57164
8.3700	3.8900	38.000	25.000	34.000	100	32.439081
8.4000	3.9000	38.000	26.000	35.000	100	32.306522
8.3700	3.8900	38.000	26.000	36.000	100	32.249711
8.3500	3.9100	38.000	27.000	37.000	100	32.136089
8.5900	3.9000	38.000	27.000	38.000	100	32.00353
8.3400	3.8900	38.000	27.000	39.000	100	31.946719
8.3200	3.9000	38.000	27.000	39.000	100	31.795223
8.2900	3.9000	38.000	28.000	39.000	100	31.700538
8.2900	3.8900	37.000	28.000	40.000	100	31.567979
8.2800	3.9000	37.000	28.000	40.000	100	31.43542
8.2300	3.8900	37.000	28.000	40.000	100	31.302861
8.2000	3.8400	37.000	28.000	40.000	100	31.227113
8.1500	3.8400	37.000	28.000	40.000	100	31.075617
8.0900	3.7500	37.000	28.000	40.000	100	30.943058
8.0400	3.6500	37.000	28.000	40.000	100	30.734751
7.8400	3.6200	37.000	28.000	40.000	100	30.469633
5.1600	2.8900	37.000	28.000	40.000	100	28.878925
6.1100	1.5500	37.000	28.000	40.000	100	27.155658
6.3200	2.1100	37.000	28.000	40.000	100	27.951012
6.4200	2.2600	37.000	28.000	40.000	100	28.159319
6.5700	2.2400	37.000	28.000	40.000	100	28.254004
7.0000	2.5300	37.000	28.000	40.000	100	27.932075
6.8700	2.5100	37.000	28.000	40.000	100	28.178256
7.0800	2.7700	37.000	28.000	40.000	100	28.159319
7.1100	2.8000	37.000	28.000	40.000	100	28.197193
7.0700	2.8800	37.000	28.000	40.000	100	28.538059
7.1500	2.9200	37.000	28.000	40.000	100	28.575933
7.2600	2.9000	37.000	28.000	40.000	100	28.59487
7.2300	2.9800	37.000	28.000	40.000	100	28.443374
7.3200	3.0300	37.000	28.000	40.000	100	28.424437
7.2700	3.0200	37.000	28.000	40.000	100	28.424437
7.3200	3.0500	37.000	28.000	40.000	100	28.500185
7.2600	2.9900	37.000	28.000	40.000	100	28.462311
7.2600	3.0800	37.000	28.000	40.000	100	28.424437
7.3700	3.1100	37.000	28.000	40.000	100	28.443374
7.3600	3.1400	37.000	28.000	40.000	100	28.197193
7.3500	3.0700	37.000	28.000	40.000	100	28.254004
7.3500	3.1200	37.000	28.000	40.000	100	28.291878
7.3300	3.1100	37.000	28.000	40.000	100	28.235067
7.3300	3.1000	37.000	28.000	40.000	100	28.159319
7.3100	3.1200	37.000	28.000	40.000	100	28.064634
7.3400	3.1100	37.000	28.000	40.000	100	28.045697
7.3100	3.1300	37.000	28.000	40.000	100	28.02676
7.3300	3.1000	37.000	28.000	40.000	100	27.969949
7.3200	3.1000	37.000	28.000	40.000	100	27.913138

Appendix 4 - Image Quality Model Sample Run

OPTICS:	
USE DIFF LIMITED lens->	NO
OQF =	1.000
LENS FILE->	
FL(mm) =	28.00
wl(um) =	0.65
F/# =	5.60

ATMOSPHERIC:	
atmos MTF =	1.000
blt MTF =	1.000

ELECTRONICS/ SUPPORT EQUIP'T/ DATA COMPRESSION/ OTHER	
ELEC MTF =	1.000
S. EQPT MTF=	1.000
D.C. MTF =	1.000
OTHER MTF =	1.000
comboMTF =	1.000

AIRCRAFT:	IN-TRK	X-TRK
ALTITUDE(FEET)=	3000	na
IN-TRACK AIRCRAFT SPEED(mph)=	100.0	0.0
INTEGRATION TIME(SEC)=	0.0167	na

DETECTOR/FPA:	IN-TRACK	X-TRACK
pixel size(μm) =	9.000	9.00
# of pixels=	2048	3060
# of transfers =	2048	3060
phase clocks =	2.000	
charge transfer =	0.99999	

	IN-TRACK	X-TRACK
GSD(ft)=	0.9642857	0.96428571

OPT cut off freq (Vo)= 274.725 lp/mm

	IN-TRK	X-TRK
AT DETECTOR nyquist limit (lp/mm)=	55.55556	55.5556
AT TARGET nyquist limit (lp/ft)=	0.51852	0.51852
theta (deg) =	30.62	30.616 (1/2 fld ang)
DIAGONAL ANGLE=		

	IN-TRACK	X-TRACK	DIAGONAL
image plane size (mm) =	18.432	27.540	33.139
1/2 angle(deg) =	18.219	26.187	30.616

AT detector FREQ (lp/mm)	v/Vnqt	at target FREQ (lp/ft)	phi(rad)	cos(phi)	sin(phi)	radial lens MTF @ field angle	tang lens MTF @ field angle	diff limited lens MTF on-axis	diff limited lens MTF OFF-axis	FREQ (lp/mm)
0.00	0.000	0.000	1.57	0.00	1.00	0.861	0.637	1.000		0.00
5.00	0.090	0.047	1.55	0.02	1.00	0.841	0.623	0.977		5.00
10.00	0.180	0.093	1.53	0.04	1.00	0.821	0.608	0.954		10.00
15.00	0.270	0.140	1.52	0.05	1.00	0.801	0.593	0.931		15.00
20.00	0.360	0.187	1.50	0.07	1.00	0.781	0.578	0.907		20.00
25.00	0.450	0.233	1.48	0.09	1.00	0.761	0.564	0.884		25.00
30.00	0.540	0.280	1.46	0.11	0.99	0.741	0.549	0.861		30.00
35.00	0.630	0.327	1.44	0.13	0.99	0.721	0.534	0.838		35.00
40.00	0.720	0.373	1.42	0.15	0.99	0.702	0.520	0.815		40.00
45.00	0.810	0.420	1.41	0.16	0.99	0.682	0.505	0.792		45.00
50.00	0.900	0.467	1.39	0.18	0.98	0.662	0.491	0.770		50.00
55.00	0.990	0.513	1.37	0.20	0.98	0.643	0.476	0.747		55.00
60.00	1.080	0.560	1.35	0.22	0.98	0.623	0.462	0.724		60.00
65.00	1.170	0.607	1.33	0.24	0.97	0.604	0.447	0.702		65.00
70.00	1.260	0.653	1.31	0.25	0.97	0.584	0.433	0.679		70.00
75.00	1.350	0.700	1.29	0.27	0.96	0.565	0.419	0.657		75.00
80.00	1.440	0.747	1.28	0.29	0.96	0.546	0.404	0.635		80.00
85.00	1.530	0.793	1.26	0.31	0.95	0.527	0.390	0.612		85.00

OQF	MEASURED TOTAL LENS MTF	FREQ (lp/mm)	clockMTF IN-TRK	detectorMTF BOTH	x-transMTF IN-TRK	x-transMTF X-TRK	total fpaMTF IN-TRK	total fpaMTF X-TRK	combo electronic MTF BOTH
		DETECTOR/FPA MTF							
1.000	1.000	0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.000
1.000	0.958	5.00	0.9992	0.9967	0.9992	0.9988	0.9950	0.9955	1.000
1.000	0.909	10.00	0.9967	0.9867	0.9968	0.9952	0.9803	0.9820	1.000
1.000	0.850	15.00	0.9925	0.9703	0.9931	0.9897	0.9564	0.9603	1.000
1.000	0.789	20.00	0.9867	0.9475	0.9883	0.9826	0.9240	0.9310	1.000
1.000	0.724	25.00	0.9793	0.9188	0.9829	0.9745	0.8844	0.8954	1.000
1.000	0.653	30.00	0.9703	0.8843	0.9772	0.9662	0.8385	0.8544	1.000
1.000	0.590	35.00	0.9597	0.8446	0.9718	0.9581	0.7877	0.8092	1.000
1.000	0.525	40.00	0.9475	0.8000	0.9670	0.9511	0.7331	0.7609	1.000
1.000	0.468	45.00	0.9339	0.7512	0.9633	0.9456	0.6758	0.7104	1.000
1.000	0.418	50.00	0.9188	0.6986	0.9608	0.9420	0.6168	0.6582	1.000
1.000	0.375	55.00	0.9022	0.6430	0.9599	0.9406	0.5568	0.6048	1.000
1.000	0.338	60.00	0.8843	0.5848	0.9605	0.9415	0.4967	0.5506	1.000
1.000	0.305	65.00	0.8651	0.5248	0.9626	0.9447	0.4371	0.4958	1.000
1.000	0.279	70.00	0.8446	0.4637	0.9661	0.9498	0.3784	0.4404	1.000
1.000	0.256	75.00	0.8229	0.4021	0.9707	0.9565	0.3212	0.3846	1.000
1.000	0.236	80.00	0.8000	0.3406	0.9760	0.9643	0.2660	0.3285	1.000
1.000	0.220	85.00	0.7761	0.2800	0.9816	0.9727	0.2133	0.2724	1.000

INTERPOLATION						
RED PIXEL						
GREEN PIXEL						
BLUE PIXEL				AIRCRAFT MOTION MTF		
				LINEAR MOTION SMEAR	IN-TRK	X-TRK
	PIXELTYPE->	GREEN		smr amt(um)=	22.8	0
				equal pixel amt =	2.53	0.00
interp	interp			IN-TRK		X-TRK
green	red or blue	Interp		system		system
MTF	MTF	MTF		smear MTF		smear MTF
BOTH	BOTH	BOTH		IN-TRK		X-TRK
1.0000	1.0000	1.0000		1.0000		1.0000
0.9901	1.0244	0.9901		0.9787		1.0000
0.9611	1.0912	0.9611		0.9166		1.0000
0.9153	1.1830	0.9153		0.8182		1.0000
0.8564	1.2765	0.8564		0.6910		1.0000
0.7891	1.3493	0.7891		0.5445		1.0000
0.7187	1.3867	0.7187		0.3891		1.0000
0.6507	1.3852	0.6507		0.2358		1.0000
0.5906	1.3531	0.5906		0.0946		1.0000
0.5432	1.3074	0.5432		-0.0259		1.0000
0.5122	1.2678	0.5122		-0.1194		1.0000
0.5001	1.2502	0.5001		-0.1821		1.0000
0.5079	1.2615	0.5079		-0.2131		1.0000
0.5348	1.2974	0.5348		-0.2143		1.0000
0.5789	1.3434	0.5789		-0.1901		1.0000
0.6365	1.3802	0.6365		-0.1466		1.0000
0.7032	1.3896	0.7032		-0.0910		1.0000
0.7735	1.3610	0.7735		-0.0311		1.0000

					NDVI		
				background	**0.407**		
				target	0.775		
				target			
				contrast =	***1.90418***		
	ATMOS MTF			MODtarget=	0.311		
						ITM	**ITM**
			total atmos			total sys	total sys
	atmos MTF	blt MTF	**MTF**			mtf	mtf
v(lp/cm)	BOTH	BOTH	BOTH		v(lp/mm)	**IN-TRK**	**X-TRK**
0.00	1.000	1.000	1.000		0.00	1.000	1.000
5.00	1.000	1.000	1.000		5.00	0.292	0.298
10.00	1.000	1.000	1.000		10.00	0.259	0.283
15.00	1.000	1.000	1.000		15.00	0.217	0.265
20.00	1.000	1.000	1.000		20.00	0.170	0.246
25.00	1.000	1.000	1.000		25.00	0.123	0.225
30.00	1.000	1.000	1.000		30.00	0.079	0.203
35.00	1.000	1.000	1.000		35.00	0.043	0.184
40.00	1.000	1.000	1.000		40.00	0.015	0.163
45.00	1.000	1.000	1.000		45.00	-0.004	0.146
50.00	1.000	1.000	1.000		50.00	-0.016	0.130
55.00	1.000	1.000	1.000		55.00	-0.021	0.117
60.00	1.000	1.000	1.000		60.00	-0.022	0.105
65.00	1.000	1.000	1.000		65.00	-0.020	0.095
70.00	1.000	1.000	1.000		70.00	-0.017	0.087
75.00	1.000	1.000	1.000		75.00	-0.012	0.080
80.00	1.000	1.000	1.000		80.00	-0.007	0.073
85.00	1.000	1.000	1.000		85.00	-0.002	0.068

	34176.4									
	5152.71									
Target (e)=	***48,100***									
Haze (e)=	***26,500***				ALT(ft) =	3000				
NOISEsys(e)=	***20***		***SNRreq=***	***1.50***						
Total(e)=	74,977		***TMv=***	***0.03***		**IN-TRK GSD(in)->**	**11.57**		**11.57**	**<-X-TRK GSD(in)**
Quant. Level=		***8***				**IN-TRK NYQT GRD(in)->**	**23.14**		**23.14**	**<- X-TRK NYQT GRD(in)**
						IN-TRK GRD(in)->	**36.73**		**23.14**	**<- X-TRK GRD(in)**
shot noise(e) =		273								
Quantized noise(e) =		84	<- STD DEV. of a normal distribution					**geo. mean GRD(in)=**		**29.16**
Noise Modulation =		0.0060			detla	delta	% of			
			TM	**TM**	**ITM - TM**	**ITM - TM**	Nyquist	IN-TRK	X-TRK	
			IN-TRK	**X-TRK**	**IN-TRK**	**X-TRK**		FREQ LIMIT	FREQ LIMIT	
			0.031	0.031	0.969	0.969	0	ok	ok	
			0.032	0.032	0.260	0.267	0.09	ok	ok	
			0.033	0.033	0.226	0.250	0.18	ok	ok	
			0.036	0.036	0.181	0.229	0.27	ok	ok	
			0.040	0.039	0.130	0.206	0.36	ok	ok	
			0.045	0.044	0.078	0.181	0.45	ok	ok	
			0.052	0.051	0.027	0.152	0.54	ok	ok	
			0.061	0.059	-0.018	0.124	0.63	35	ok	
			0.072	0.070	-0.057	0.094	0.72	40	ok	
			0.085	0.081	-0.089	0.065	0.81	45	ok	
			0.099	0.093	-0.115	0.037	0.90	50	ok	
			0.112	0.103	-0.134	0.013	0.99	55	ok	
			0.124	0.112	-0.147	-0.007	1.08	60	60	
			0.134	0.118	-0.154	-0.023	1.17	65	65	
			0.143	0.123	-0.159	-0.036	1.26	70	70	
			0.153	0.128	-0.165	-0.048	1.35	75	75	
			0.167	0.136	-0.174	-0.062	1.44	80	80	
			0.190	0.149	-0.192	-0.080	1.53	85	85	

90.00	1.620	0.840	1.24	0.33	0.94	0.508	0.376	0.590	90.00
95.00	1.710	0.887	1.22	0.35	0.94	0.489	0.362	0.569	95.00
100.00	1.800	0.933	1.20	0.36	0.93	0.471	0.349	0.547	100.00
105.00	1.890	0.980	1.18	0.38	0.92	0.452	0.335	0.525	105.00
110.00	1.980	1.027	1.16	0.40	0.92	0.434	0.321	0.504	110.00
115.00	2.070	1.073	1.14	0.42	0.91	0.416	0.308	0.483	115.00
120.00	2.160	1.120	1.12	0.44	0.90	0.398	0.295	0.462	120.00
125.00	2.250	1.167	1.10	0.46	0.89	0.380	0.281	0.441	125.00

F56BT(F/5.6;BEST,WITH 650BPFILTER,FLD=-50DEG, RADSCAN)

FREQ (lp/mm)	*input* ***LENS MTF***
0.00	***1.000***
5.00	***0.958***
10.00	***0.909***
15.00	***0.850***
20.00	***0.789***
25.00	***0.724***
30.00	***0.653***
35.00	***0.590***
40.00	***0.525***
45.00	***0.468***
50.00	***0.418***
55.00	***0.375***
60.00	***0.338***
65.00	***0.305***
70.00	***0.279***
75.00	***0.256***
80.00	***0.236***
85.00	***0.220***
90.00	***0.206***
95.00	***0.193***
100.00	***0.181***
105.00	***0.169***
110.00	***0.157***
115.00	***0.146***
120.00	***0.135***
125.00	***0.123***

1.000	0.206	90.00	0.7512	0.2209	0.9871	0.9809	0.1638	0.2167	1.000
1.000	0.193	95.00	0.7254	0.1638	0.9921	0.9882	0.1179	0.1619	1.000
1.000	0.181	100.00	0.6986	0.1093	0.9961	0.9942	0.0761	0.1087	1.000
1.000	0.169	105.00	0.6712	0.0579	0.9988	0.9982	0.0388	0.0578	1.000
1.000	0.157	110.00	0.6430	0.0101	1.0000	0.9999	0.0065	0.0101	1.000
1.000	0.146	115.00	0.6142	-0.0337	0.9995	0.9993	-0.0207	-0.0337	1.000
1.000	0.135	120.00	0.5848	-0.0733	0.9975	0.9962	-0.0428	-0.0730	1.000
1.000	0.123	125.00	0.5550	-0.1083	0.9940	0.9911	-0.0597	-0.1073	1.000

0.8420	1.2951	0.8420		0.0259			1.0000	
0.9032	1.2045	0.9032		0.0737			1.0000	
0.9523	1.1102	0.9523		0.1079			1.0000	
0.9852	1.0361	0.9852		0.1258			1.0000	
0.9995	1.0012	0.9995		0.1268			1.0000	
0.9940	1.0149	0.9940		0.1123			1.0000	
0.9691	1.0735	0.9691		0.0853			1.0000	
0.9268	1.1616	0.9268		0.0501			1.0000	

	90.00	1.000	1.000	1.000		90.00	0.002	0.064
	95.00	1.000	1.000	1.000		95.00	0.004	0.060
	100.00	1.000	1.000	1.000		100.00	0.006	0.056
	105.00	1.000	1.000	1.000		105.00	0.007	0.053
	110.00	1.000	1.000	1.000		110.00	0.006	0.049
	115.00	1.000	1.000	1.000		115.00	0.005	0.045
	120.00	1.000	1.000	1.000		120.00	0.004	0.042
	125.00	1.000	1.000	1.000		125.00	0.002	0.038

0.227	0.172	-0.225	-0.107	1.62	90	90
0.294	0.214	-0.290	-0.154	1.71	95	95
0.432	0.303	-0.426	-0.246	1.80	100	100
0.818	0.550	-0.812	-0.497	1.89	105	105
4.823	3.101	-4.817	-3.052	1.98	110	110
-1.520	-0.934	1.525	0.979	2.07	ok	ok
-0.755	-0.442	0.759	0.484	2.16	ok	ok
-0.565	-0.315	0.567	0.353	2.25	ok	ok
					35	60
					35	55.5556

Appendix 5 - Image Processing Diagram

CIR Camera Image Processing

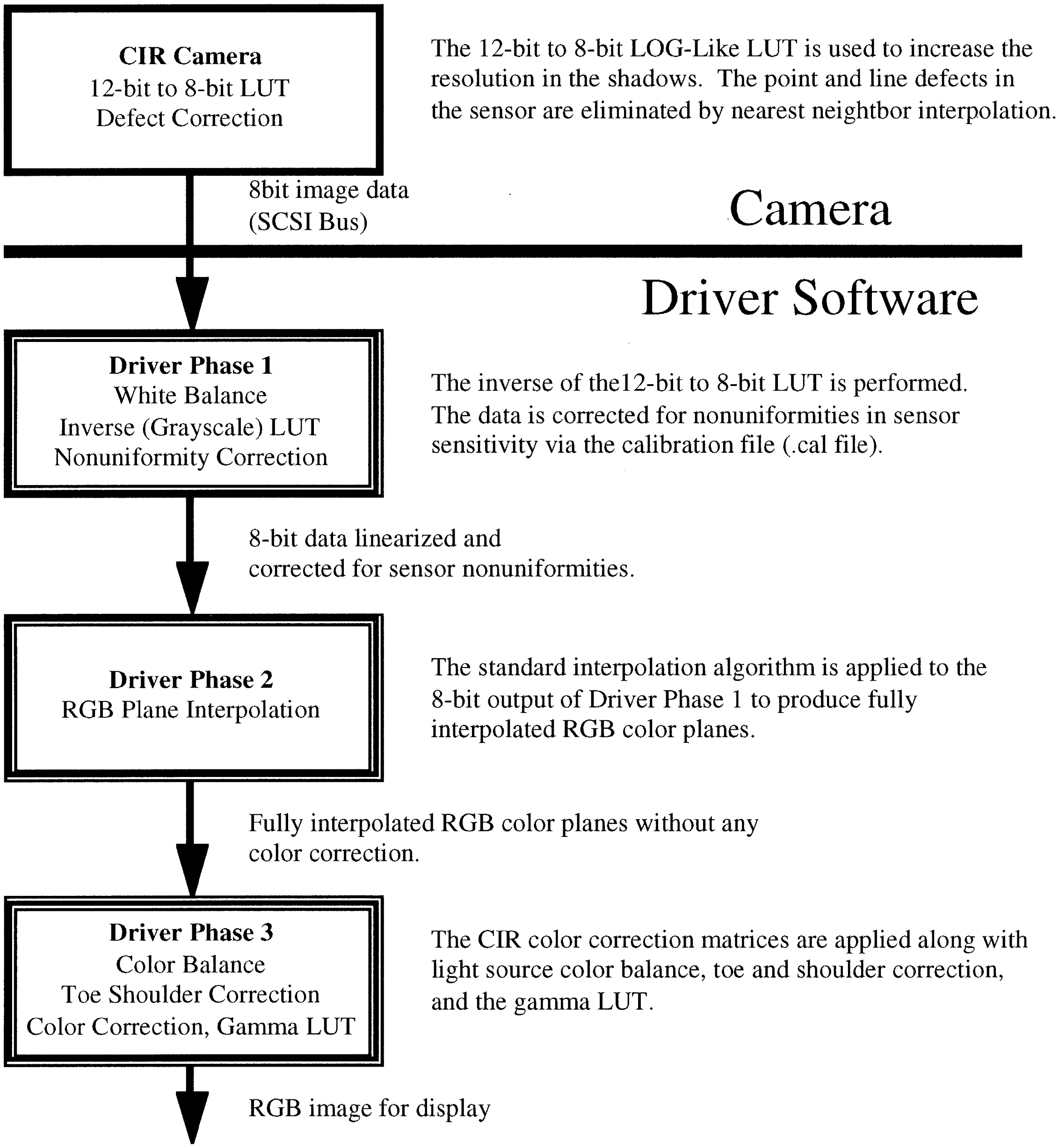

Figure 25: The CIR Camera Image Processing Diagram

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