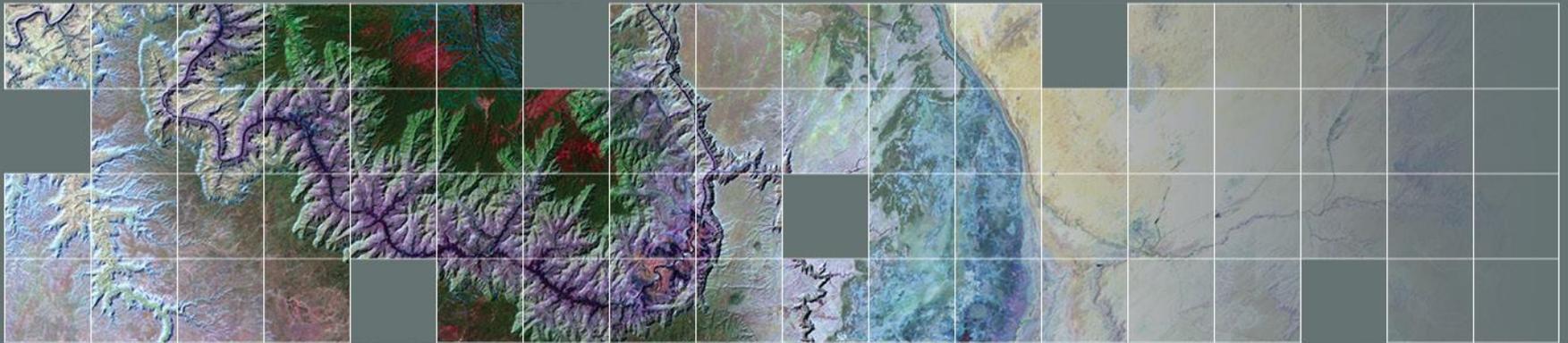


Climate and Land Use Change

Earth Resources Observation and Science (EROS) Center

A look at SPOT 7 and SkySat data



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5/6/2015**

Outline

- **SPOT 7**
 - Data Overview
 - Geometry
 - Radiometry
- **SkySat**
 - Geometry
 - MTF assessments
- **Summary**

SPOT 7 Data overview

- **Data from SPOT 7**
 - Sioux Falls
 - Pueblo
 - Rail Road Valley
- **Four spectral bands**
 - Blue, Green, Red, Near Infrared
- **Ground sampling distance: 1.5 m (PAN), 6 m (MSS)**
- **Data for analysis in WGS UTM Zone 13N (Pueblo) and 14N (Sioux Falls)**
- **Reference data: Orthoimagery**

Spectral Bands

Spectral Bands	Wavelength (μm)	
	SPOT 7	Landsat 8
Blue	0.450 – 0.520	0.45 – 0.51
Green	0.530 – 0.590	0.53 – 0.59
Red	0.625 – 0.695	0.64 – 0.67
NIR	0.760 – 0.890	0.85 – 0.88
Pan	0.450 – 0.745	0.50 – 0.68

- Red, NIR and Panchromatic bands are significantly different from Landsat

Geometric Accuracy Assessment

- **Performed using the Landsat Image Assessment System (IAS)**
 - Developed for Radiometric and Geometric Characterization and Calibration for Landsat data.
- **Band to Band (B2B) assessment**
 - B2B is performed to test band alignment of the image data
 - It is typically done by registering each band against every other band
- **Image to Image registration assessment tool**
 - Image Matching is usually performed to compare the relative accuracy between two images
 - Performed against an image of higher accuracy (reference data)
 - The results provide an insight to the relative accuracy of the search image with respect to the reference image
 - When the correlated points are plotted in the image, it also helps to detect any systematic bias in the image

SPOT 7 Geometric Data Analysis

- Image matching using Orthoimagery as control data for MSS and PAN data
- Coordinate System: WGS 84 UTM Zone 13N for Pueblo and Zone 14 N for Sioux Falls data
- Semi Automated
 - Since data were over cities, uniform selection of points would likely lose points over buildings etc.
 - Therefore several sub-images were chosen
- Image Matching performed for sub images

SPOT 7 Geometric results

Summary statistics for SPOT 7 PAN band analysis: Pueblo

Pueblo I2I analysis PAN Band	X	Y
	Meters	
Mean	3.65	-3.25
StDev	1.28	0.87
RMSE	4.0	3.5
Total RMSE	5.3 meters (3.5 pixels)	

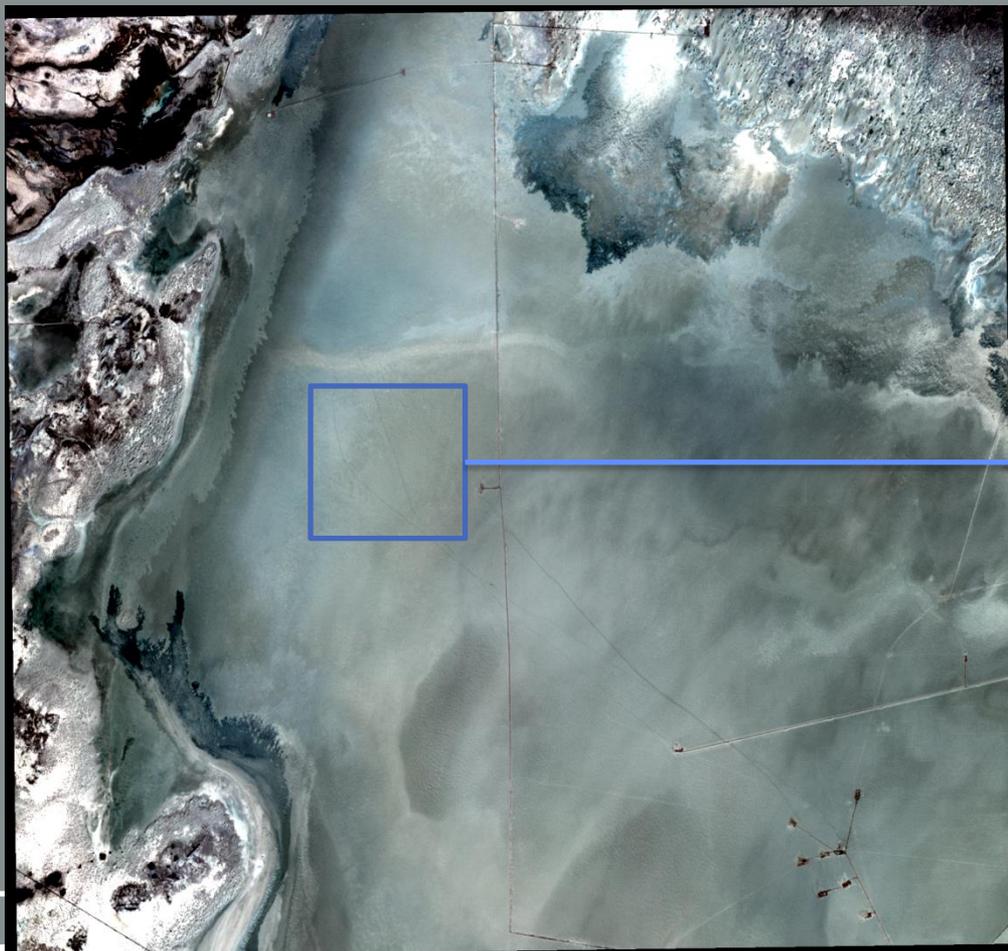
Summary statistics for SPOT 7 PAN band analysis: Sioux Falls

Sioux Falls I2I analysis PAN Band	X	Y
	Meters	
Mean	1.77	1.72
StDev	1.89	1.66
RMSE	2.64	2.44
Total RMSE	3.6 meters (2.4 pixels)	

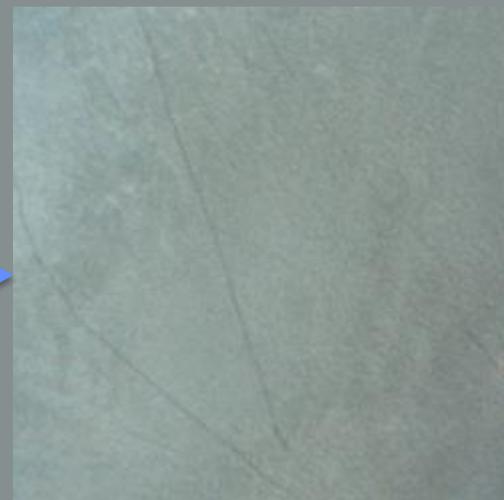
RMSE for MSS data < 1.5 pixels @ 6 m pixels in Pueblo and Sioux Falls

MSS bands are registered to within 0.28 pixels of each other

SPOT 7 Image over Rail Road Valley



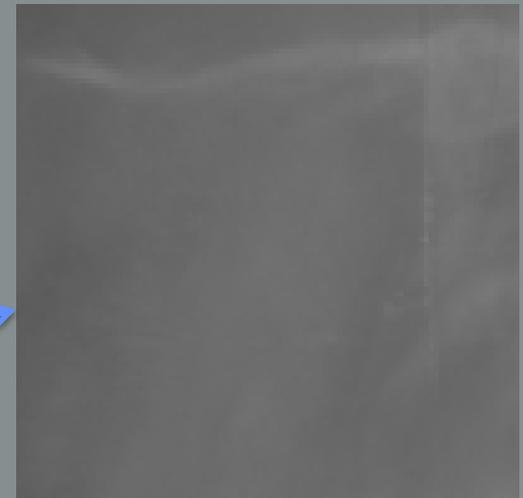
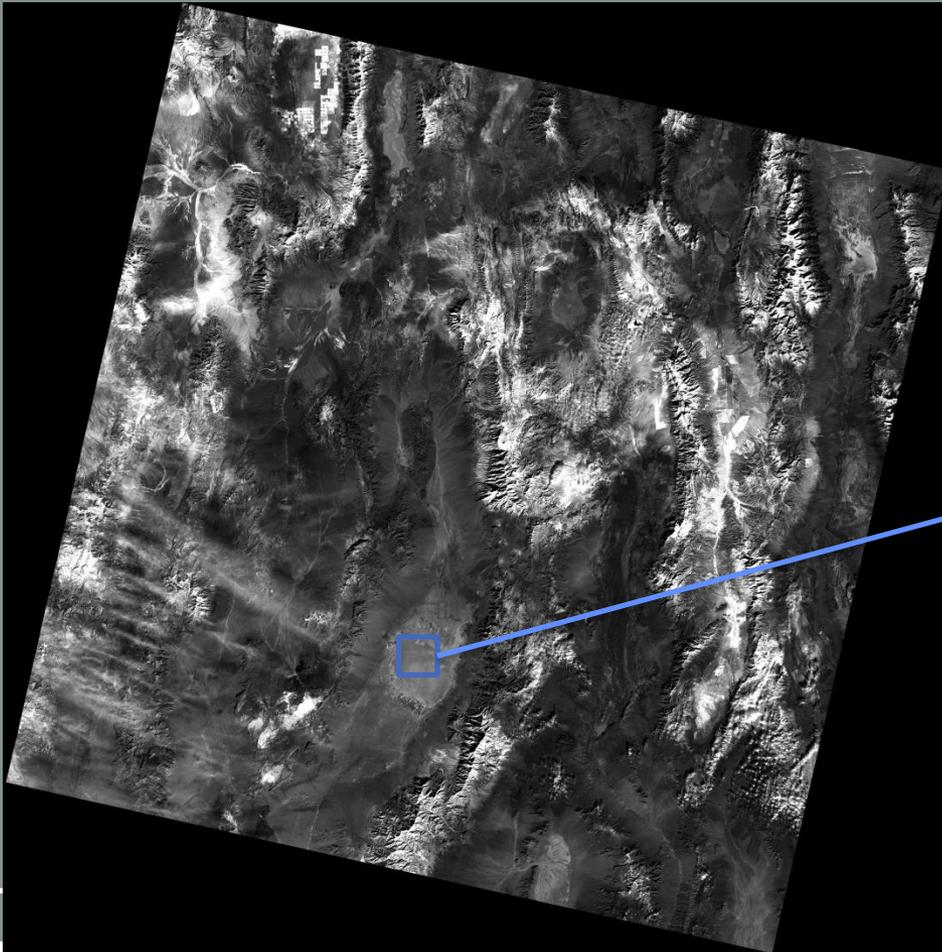
- Imaged on Dec-08-2014



ROI Lat: 38, 30, 26.17
ROI Lon: -115, 42, 9.09
250 X 250 pixels

Landsat 8 Image over Rail Road Valley

- Imaged on Dec-19-2014



ROI Lat: 38, 30, 26.07
ROI Lon: -115, 42, 7.97
50 X 50 pixels

TOA Reflectance over Rail Road Valley

	TOA Reflectance	
	SPOT 7	Landsat 8
Blue	0.2583	0.2037
Green	0.2859	0.2223
Red	0.3156	0.2527
NIR	0.3452	0.3014

Observations

- **From the test site SPOT 7 reflectance is higher than Landsat 8 reflectance**
 - Spectral differences are not accounted for
 - Landsat image was cloudy
 - SPOT 7 and Landsat 8 images were acquired 11 days apart
 - Observed region might have changed
 - Need more investigation to find out if some differences are related to radiometric calibration

SkySat-1

- **Frame camera instead of traditional scanning technology**
- **Collects imagery or video at 30 frames per second**
- **Five image bands**
 - Four multispectral
 - One Panchromatic
- **Image processing includes RPC models, internal sensor geometry, sensor position and sensor orientation**

Sample scene

- CatalogID:
S01_20150126T165015Z
- The image consists of six tiles
- The thumbnail image is a mosaic image of the tiles
- Each tiles consists of panchromatic, multispectral and pan-sharpened images



Image Dynamic Range

Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	119	4094	248.764	60.8761	150	454	304	9
1	118	1222	143.646	27.3343	125	243	118	7
2	60	943	96.223	28.3925	71	204	133	8
3	31	938	72.595	35.3091	41	200	159	8
4	11	755	141.323	36.3903	17	221	204	8

Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	102	2099	246.808	49.8554	157	395	238	8
1	117	1037	141.262	18.3784	124	210	86	7
2	58	990	93.719	20.2513	71	175	104	7
3	30	998	71.8524	27.1832	43	173	130	8
4	11	812	139.075	31.4072	59	214	155	8

Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	120	1245	254.672	63.5535	160	551	391	9
1	119	534	149.301	22.6155	127	259	132	8
2	61	542	102.086	30.818	73	253	180	8
3	31	608	82.0396	38.5297	44	278	234	8
4	8	564	129.478	39.3192	28	243	215	8

Image Dynamic Range

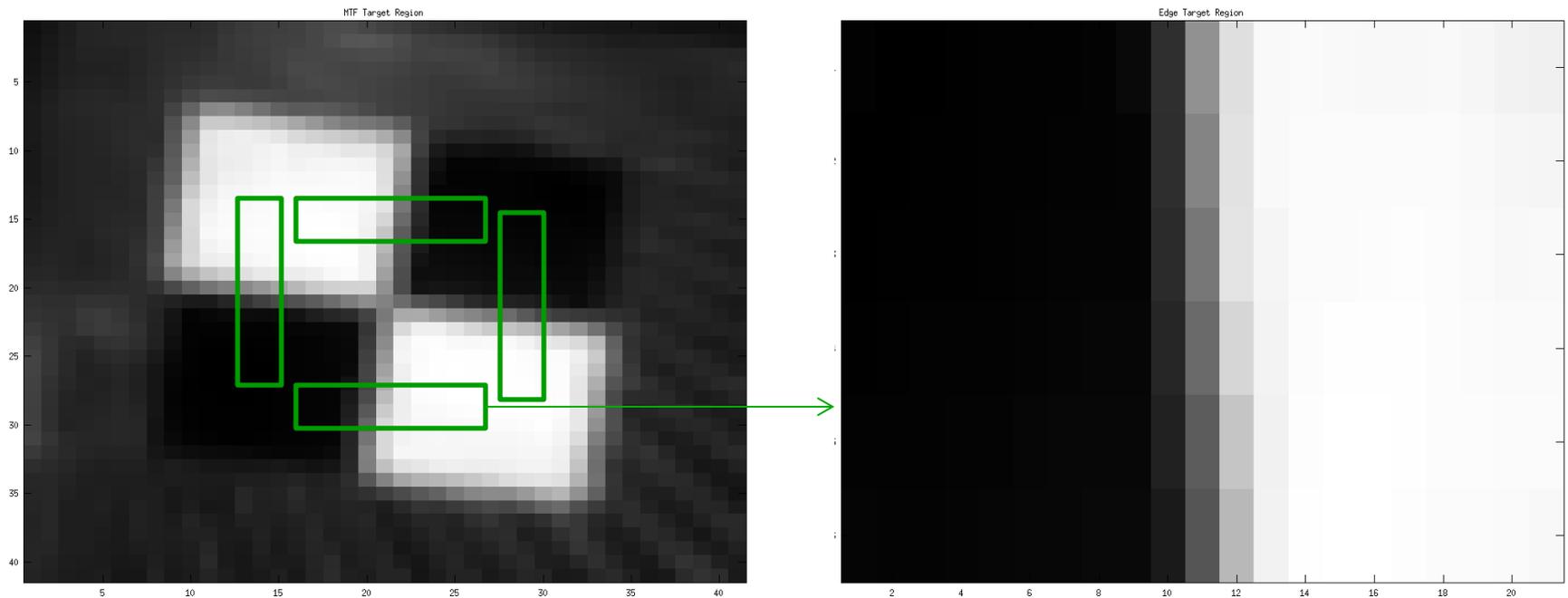
Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	116	1767	259.287	51.1501	163	415	252	8
1	121	847	147.438	19.2616	128	223	95	7
2	61	756	99.5343	22.8855	72	206	134	8
3	32	719	77.5505	30.5459	42	195	153	8
4	11	543	144.358	34.5544	29	224	195	8

Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	122	2566	259.103	73.5785	149	534	385	9
1	121	962	152.878	32.6341	128	281	153	8
2	64	878	104.027	33.0951	74	237	163	8
3	33	870	83.826	38.4057	45	233	188	8
4	13	721	134.642	43.9532	19	240	221	8

Band#	Min(DN)	Max(DN)	Mean(DN)	Std Dev(DN)	Min(1%)(DN)	Max(1%)(DN)	Dyan. Range	Effec Rad Res (bits)
0	139	846	241.821	29.5889	175	308	133	8
1	125	346	156.957	8.74893	136	175	39	6
2	67	284	105.265	9.7169	81	125	44	6
3	40	260	84.9309	10.5734	58	107	49	6
4	18	251	94.0315	20.4161	36	146	110	7

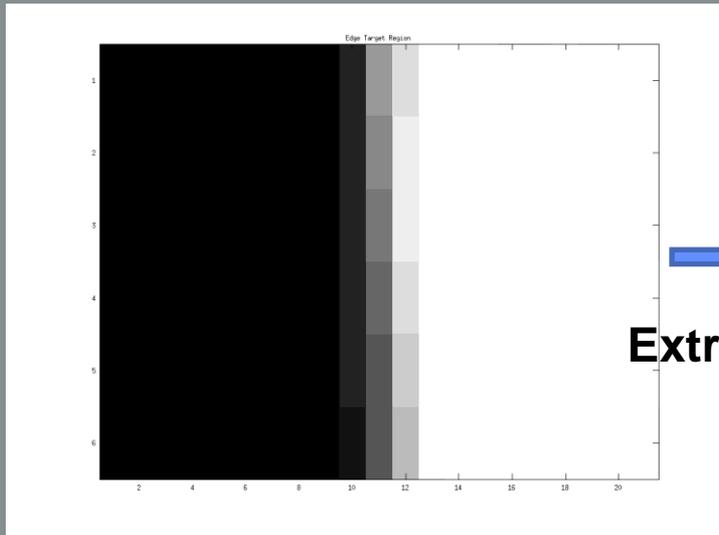
MTF Estimation using Edge Profile

- From the MTF target select a region with transition from dark to bright or bright to dark
 - Horizontal direction
 - Vertical direction

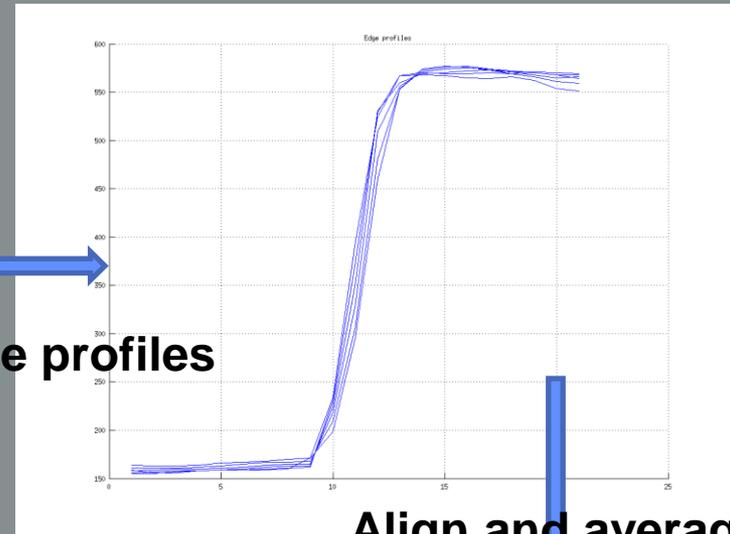


SkySat-1 over Stennis MTF Target
Acquisition date 1/26/2015

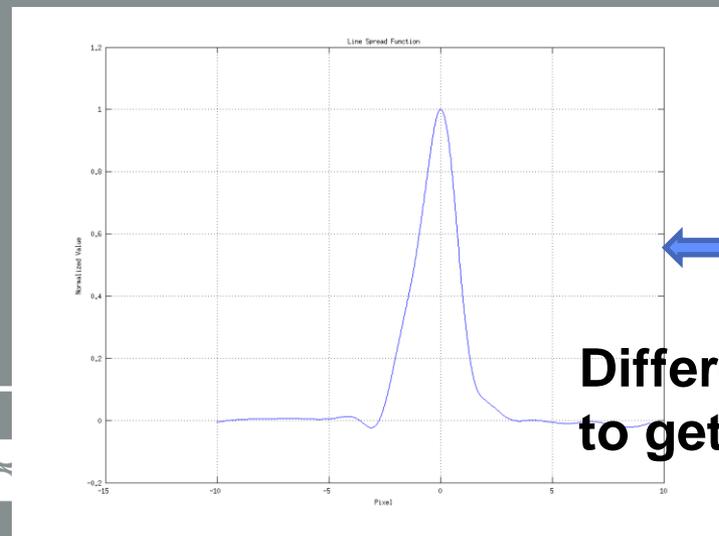
MTF Estimation using Edge Profile -2/3



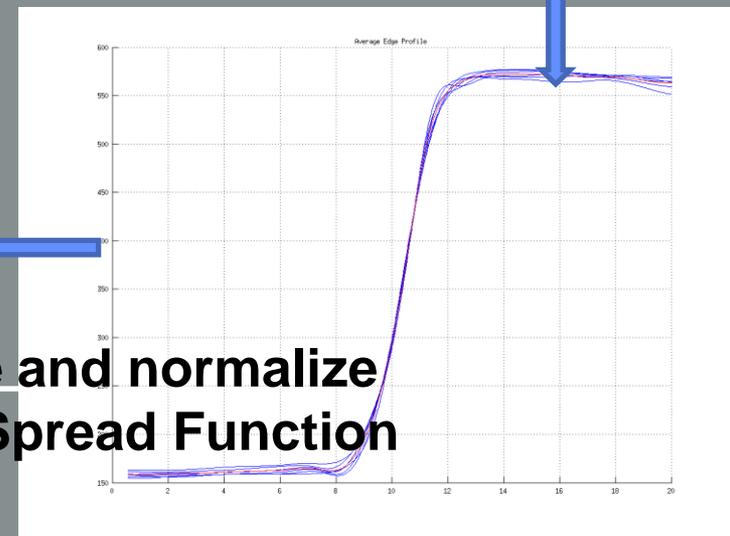
Extract edge profiles



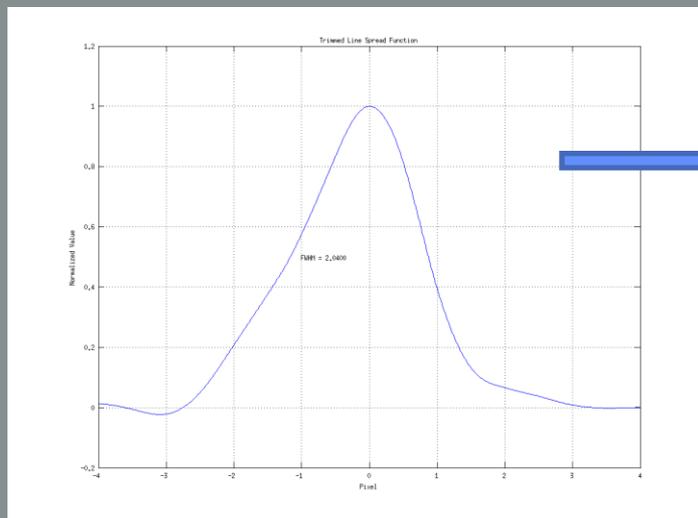
Align and average



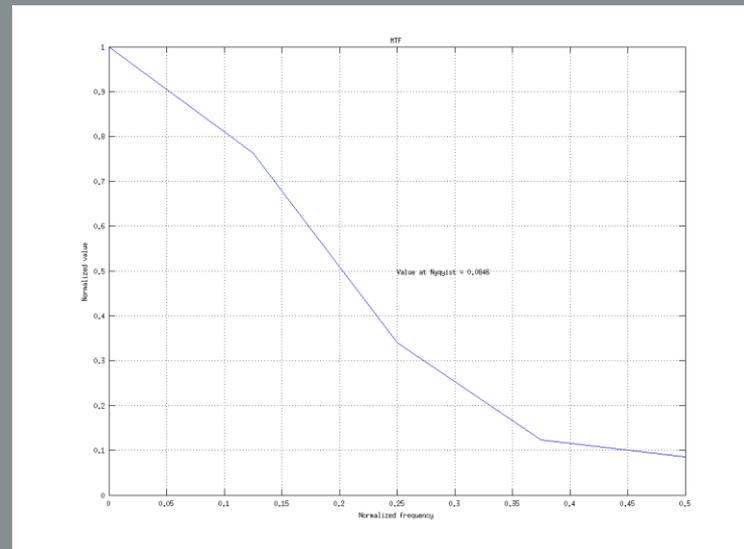
Differentiate and normalize to get Line Spread Function



MTF Estimation using Edge Profile -3/3

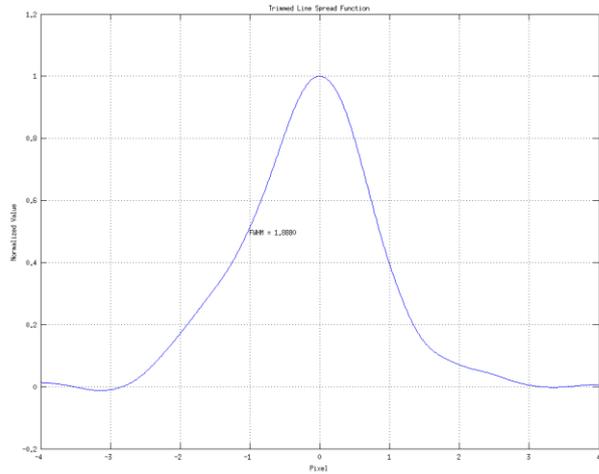


FFT

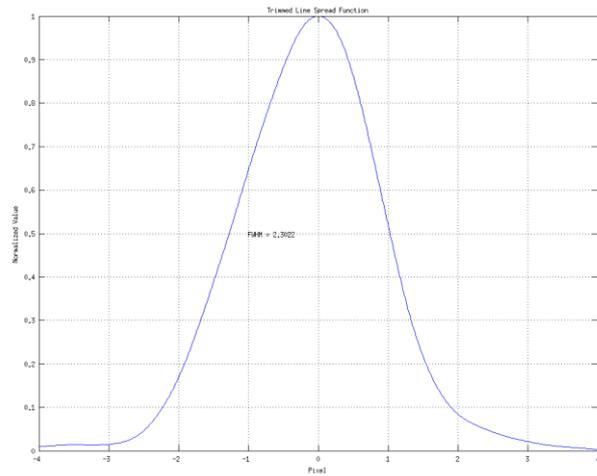
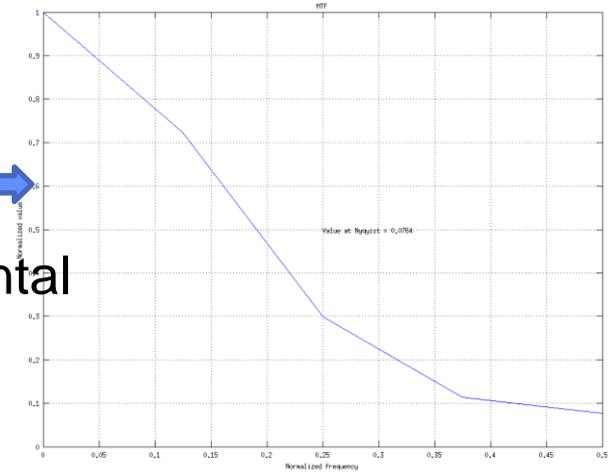


- **Take FFT of Line Spectrum Function (LSF) to get Modulation Transfer Function (MTF)**
 - Estimate Full Width at Half Maxima (FWHM) from LSF
 - Estimate MTF at Nyquist frequency

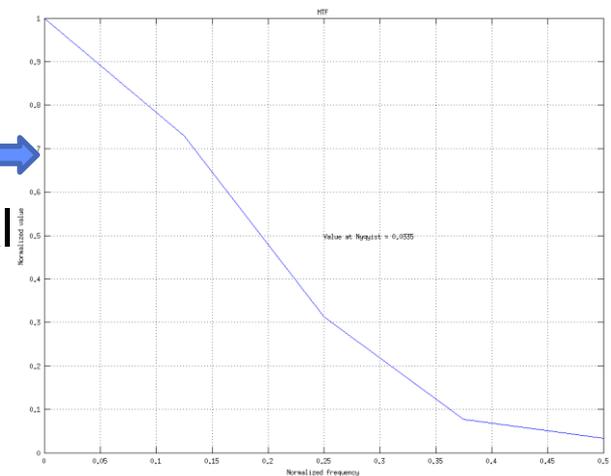
LSF and MTF - B1



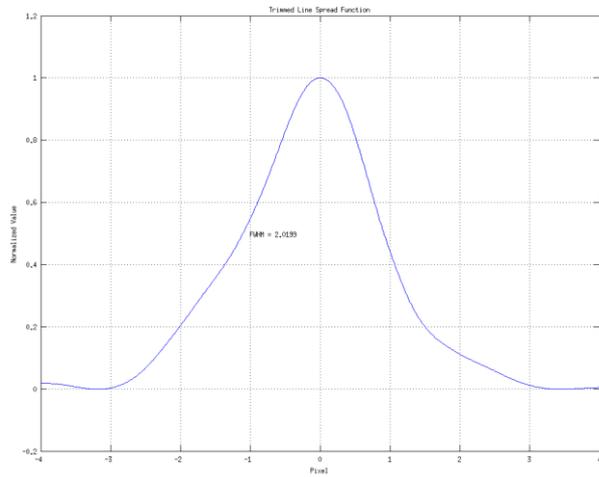
Horizontal



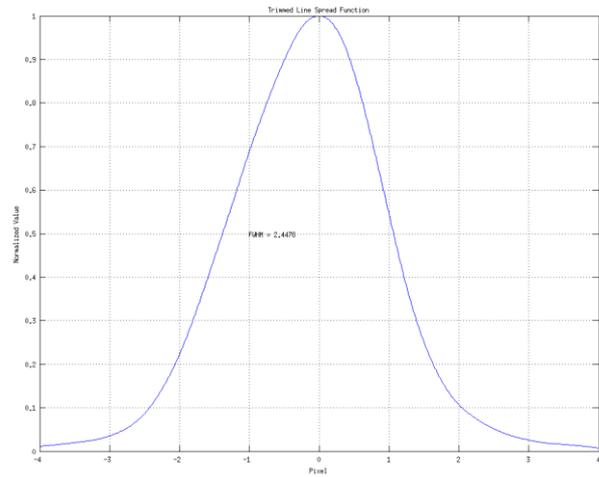
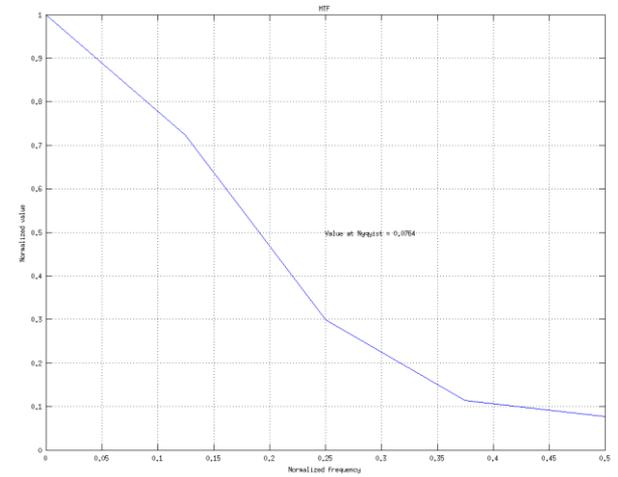
Vertical



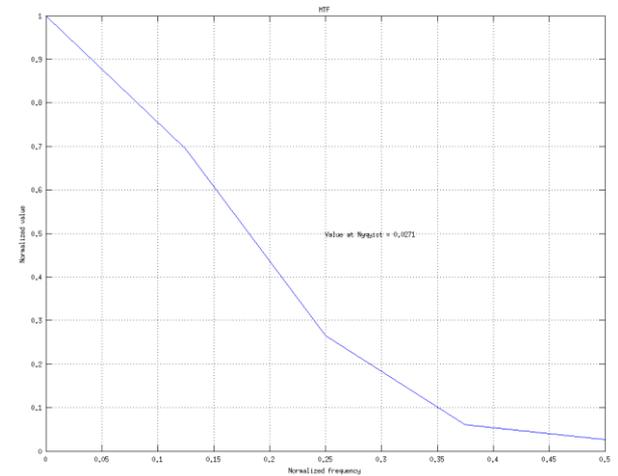
LSF and MTF – B2



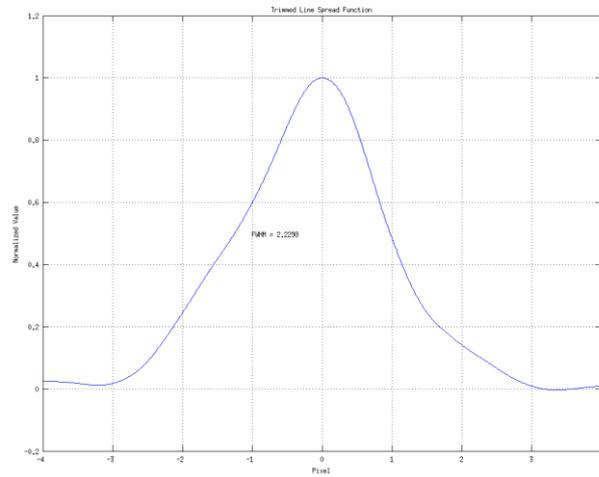
Horizontal



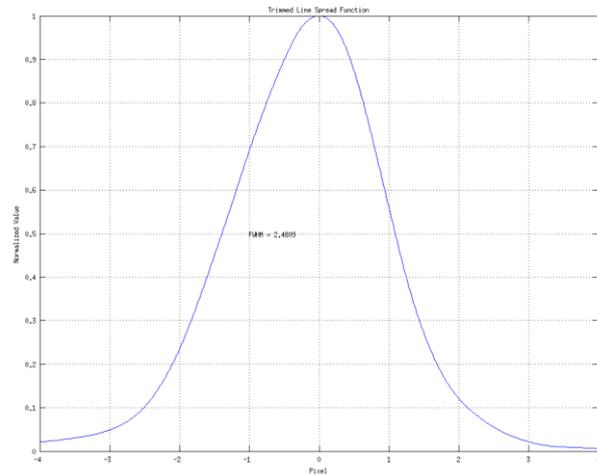
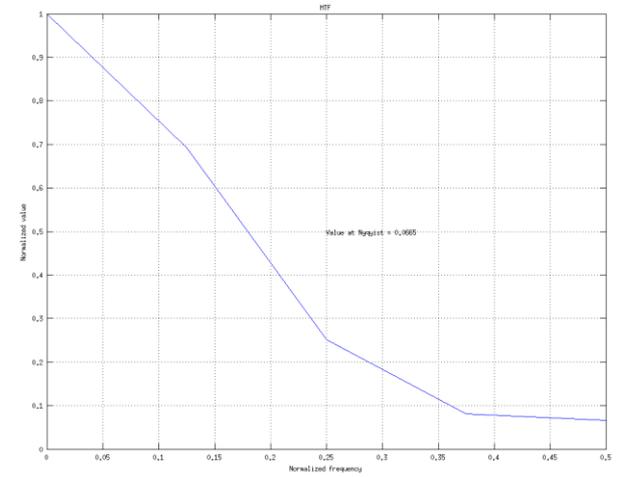
Vertical



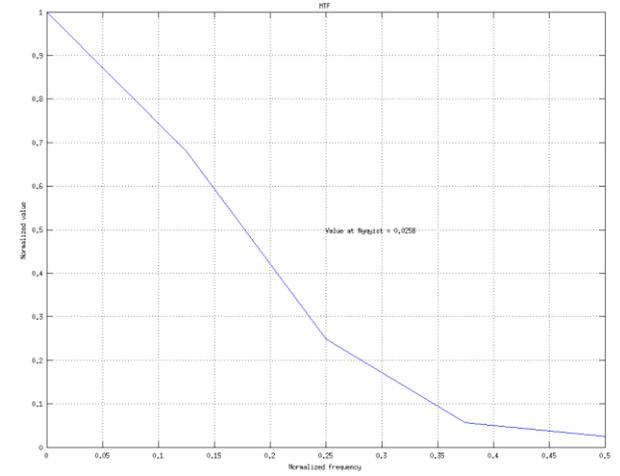
LSF and MTF – B3



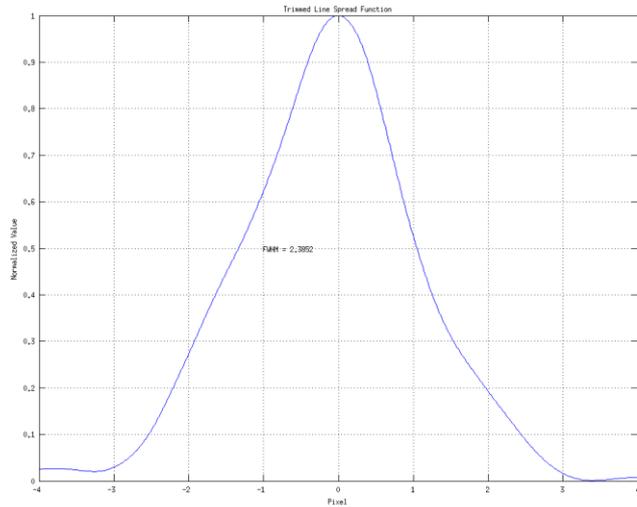
Horizontal



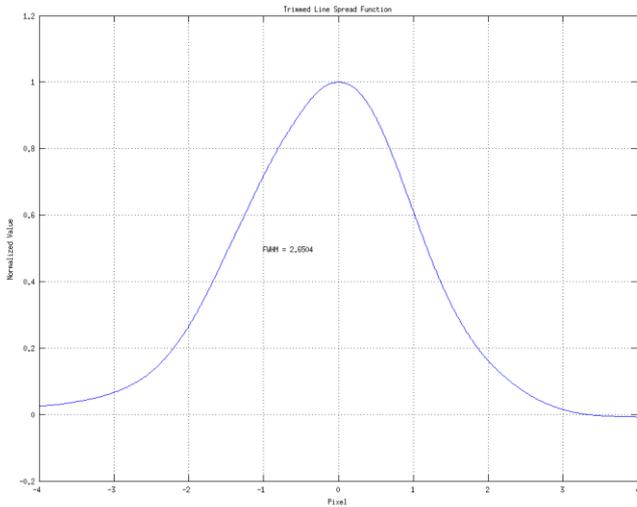
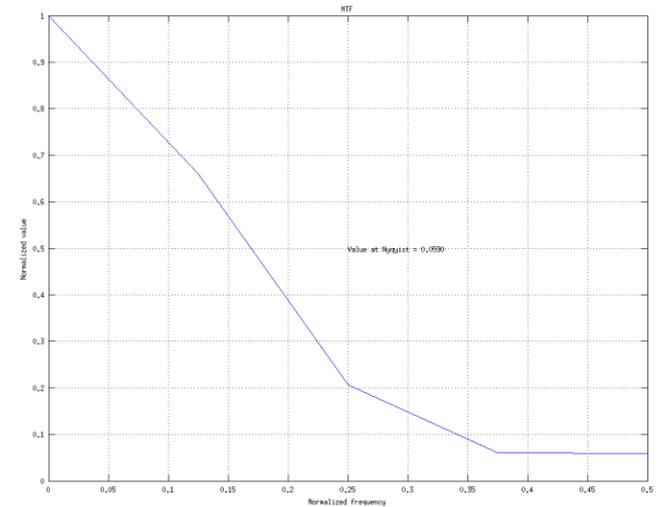
Vertical



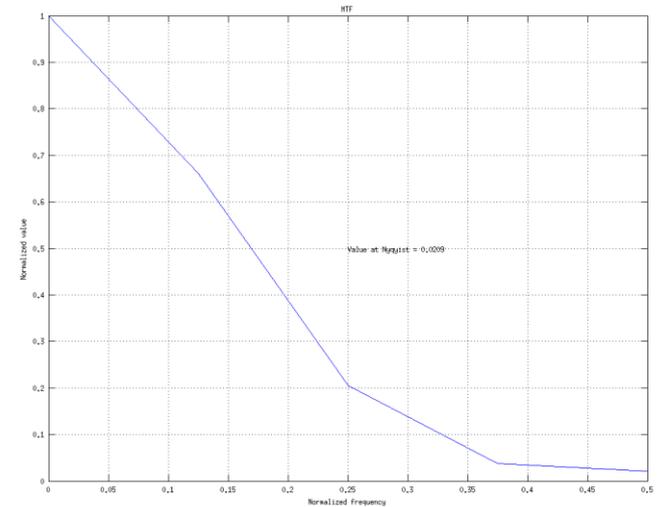
LSF and MTF – B4



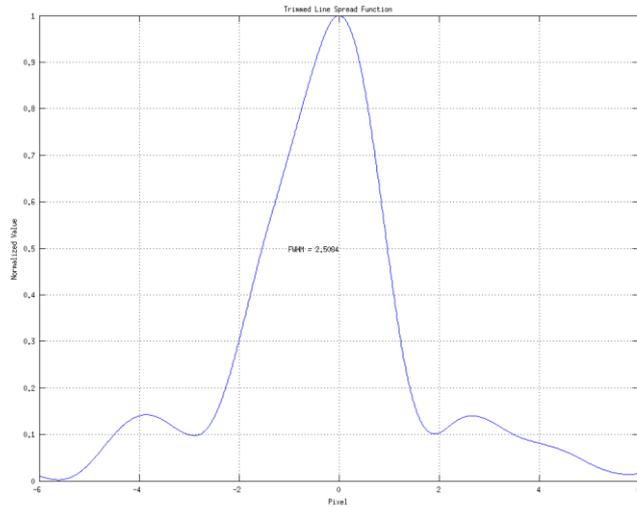
Horizontal



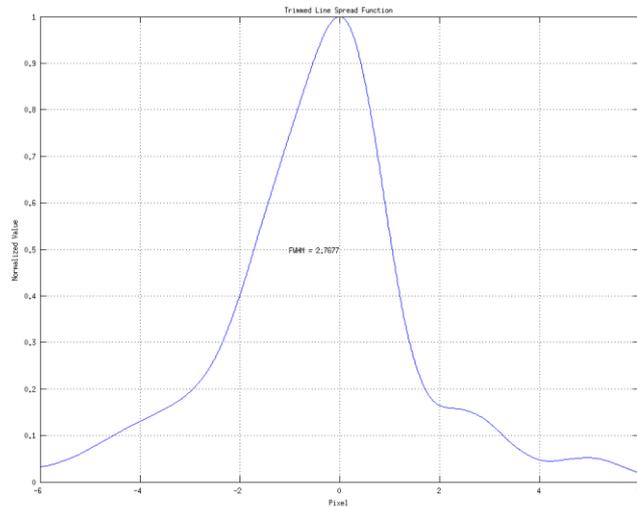
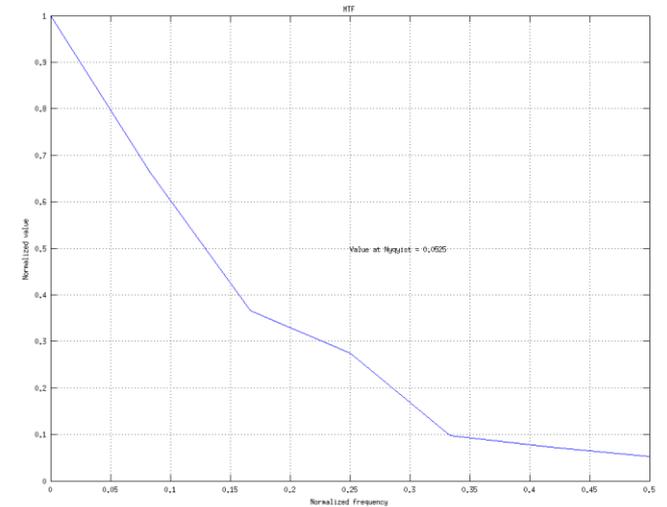
Vertical



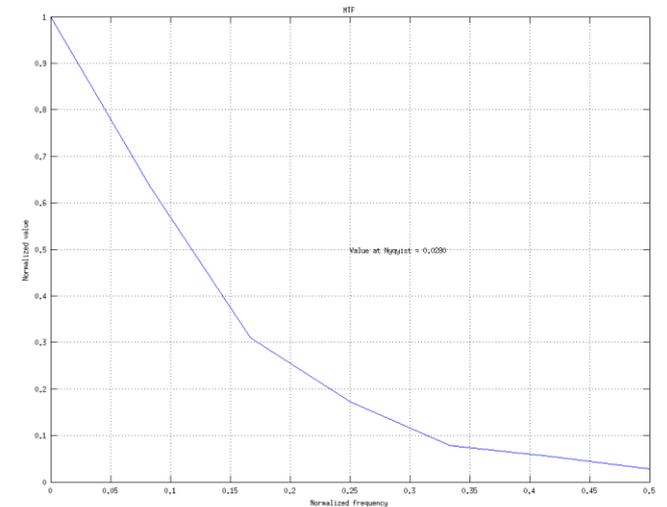
LSF and MTF – Pan Band



Horizontal



Vertical



FWHM and MTF@Nyquist (%)

Band	Direction	FWHM	<u>MTF@Nyquist</u>
MS-1	Horizontal-1	2.04	8.46
	Horizontal-2	1.89	8.82
	Vertical-1	2.3	3.35
	Vertical-2	2.29	2.07

Band	Direction	FWHM	<u>MTF@Nyquist</u>
MS-2	Horizontal-1	2.19	7.6
	Horizontal-2	2.02	7.64
	Vertical-1	2.45	2.71
	Vertical-2	2.4	1.99

Band	Direction	FWHM	<u>MTF@Nyquist</u>
MS-3	Horizontal-1	2.41	6.32
	Horizontal-2	2.23	6.65
	Vertical-1	2.48	2.58
	Vertical-2	2.48	1.55

Band	Direction	FWHM	<u>MTF@Nyquist</u>
MS-4	Horizontal-1	2.66	5.52
	Horizontal-2	2.39	5.9
	Vertical-1	2.65	2.09
	Vertical-2	2.62	1.44

Band	Direction	FWHM	<u>MTF@Nyquist</u>
Pan	Horizontal-1	2.6	4.54
	Horizontal-2	2.51	5.25
	Vertical-1	2.77	2.8
	Vertical-2	2.93	1.94

Observations

- Limited number of scenes were analyzed
- Some artifacts like noise and blurred edges were observed
- MTF in horizontal direction is better than MTF in vertical direction
- Band 1 MTF is better than MTF in other bands
- It was difficult to extract good edge profiles for MTF estimation

Summary

- **SPOT 7 and SkySat Characterizations performed**
 - Proba V and WorldDEM will be presented later today
- **Future Analysis:**
 - Continued data assessments for Medium to High resolution datasets ..
 - Elevation data characterizations
 - Pleiades Stereo pair data
 - Working with WorldDEM
 - More data are welcome
 - More collaborations welcome