A comparison of commercial Pan-sharpening techniques for HR Satellite imagery

ESRI International User Conference 2013

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Contents

- Why pansharpening ?
- Pansharpening comparison
- FuzeGo Pansharpening
- Conclusion

Importance of pan-sharpening

- More than 70% of optical satellites simultaneously collect a low resolution MS image and a high resolution Pan image.
- Most remote sensing and GIS applications desire high resolution colour image.
- Effective and high quality pan-sharpening technique is crucial for the success of many GIS/remote sensing applications.
- Research on pan-sharpening has been conducted since the mid-1980s.

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image fusion techniques

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Multisensor **image fusion techniques** in remote sensing — isprs.org [PDF]
M Ehlers - ISPRS Journal of Photogrammetry and Remote ..., 1991 - Elsevier — Check for fulltext @ UNB
Abstract Current and future remote sensing programs such as Landsat, SPOT, MOS, ERS, JERS, and the space platform's Earth Observing System (Eos) are based on a variety of imaging sensors that will provide timely and repetitive multisensor earth observation data ...
Cited by 213 Related articles All 5 versions Cite

[BOOK] Introduction — revues.org [HTML]
HB Mitchell - 2010 - Springer
... A study of existing **image fusion techniques** and applications shows that **image fusion** can provide us with an output **image** with an improved quality. ... The aim is to illustrate how the theories and **techniques** of **image fusion** are used in practical situations. 1.7 Software ...
Cited by 6808 Related articles All 19 versions Cite More

Image fusion techniques for remote sensing applications — unitn.it [PDF]
G Simone, A Farina, FC Morabito, SB Serpico... - Information **fusion**, 2002 - Elsevier — Check for fulltext @ UNB
Image fusion refers to the acquisition, processing and synergistic combination of information provided by various sensors or by the same sensor in many measuring contexts. The aim of this survey paper is to describe three typical applications of data **fusion** in remote sensing. ...
Cited by 220 Related articles All 12 versions Cite

[PDF] **Image fusion techniques** — doaj.org [PDF]
A Umaamaheshvari, K Thanushkodi - International Journal, 2010 - doaj.org
ABSTRACT The conventional **image** embedding technique is watermarking which applies DCT to the host **image**. The problem appeared in this technique is that the size of the host **image** should be greater than the signature **image**, thereby reducing the signal to noise ...
Cited by 1 Related articles All 5 versions Cite More

Wavelet based **image fusion techniques**—An introduction, review and comparison — Check for fulltext @ UNB
K Amolins, Y Zhang, P Dare - ISPRS Journal of Photogrammetry and ..., 2007 - Elsevier
Image fusion involves merging two or more images in such a way as to retain the most desirable characteristics of each. When a panchromatic **image** is fused with multispectral imagery, the desired result is an **image** with the spatial resolution and quality of the ...
Cited by 200 Related articles All 6 versions Cite

[PDF] Understanding **image fusion** — unb.ca [PDF]
Y Zhang - Photogrammetric engineering and remote sensing, 2004 - studio.gge.unb.ca

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Pan sharpening techniques

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Process for enhancing the spatial resolution of multispectral imagery using **pan-sharpening** patents.com [HTML]
CA Laben, BV Brower - US Patent 6,011,875, 2000 - Google Patents
... Two widely used **pan-sharpening techniques**, as described in "Compari- son of Three Different Methods to Merge Multiresolution and Multispectral Data", Chavez et al, Photogrammetric Engineering & Remote Sensing, March 1991, pages 295-303, are the Intensity, Hue, and ...
Cited by 224 Related articles All 4 versions Cite

Kodak's patent

On the performance evaluation of **pan-sharpening techniques** researchgate.net [PDF]
Q Du, NH Younan, R King... - Geoscience and Remote ..., 2007 - ieeexplore.ieee.org Check for fulltext @ UNB
Abstract The limitations of the currently existing **pan-sharpening** quality indices are analyzed: the absolute difference between pixel values, mean shifting, and dynamic range change is frequently used as spatial fidelity measurement, but they may not correlate well ...
Cited by 31 Related articles All 8 versions Cite

An IHS and wavelet integrated approach to improve **pan-sharpening** visual quality of natural colour IKONOS and QuickBird images Check for fulltext @ UNB
Y Zhang, G Hong - Information Fusion, 2005 - Elsevier
... Fusion of Remotely Sensed Data over Urban Areas. Cover image. An IHS and wavelet integrated approach to improve **pan-sharpening** visual quality of natural colour IKONOS and QuickBird images. ... To date, many image fusion **techniques** have been developed. ...
Cited by 161 Related articles All 2 versions Cite

Yun Zhang's paper

Enhancing the resolution of multi-spectral image data with panchromatic image data using super resolution **pan-sharpening**
PW Yuen - US Patent 5,949,914, 1999 - Google Patents
... Assistant Examiner—Dmitry A. Novik Attorney, Agent, or Firm—William W. Cochran, II [57] ABSTRACT The present invention discloses a super resolution **pan- sharpening technique** that is used to increase the resolution of a multi-spectral signal using a panchromatic signal. ...
Cited by 54 Related articles All 2 versions Cite

A wavelet based algorithm for **pan sharpening** Landsat 7 imagery Check for fulltext @ UNB
RL King, J Wang - ... Symposium, 2001. IGARSS'01. IEEE 2001 ..., 2001 - ieeexplore.ieee.org
... spatial domain **techniques** try to convert all radiomemic information from high-resolution imagery to low-r{.solution imagery. Obviously, a combination of both approaches would lead to an optim result. The following steps summarize the **pan sharpening** algorithm developed ...
Cited by 51 Related articles Cite

SpaceImaging's patent

Tens of thousands papers on pan-sharpening haves been published,
only a few outstanding pan-sharpening algorithms have been adopted by industry.

Widely used commercial pan-sharpening algorithms

ERDAS IMAGINE:

- Subtractive Resolution Merge
- HPF Resolution Merge
- Modified IHS Resolution Merge
- Wavelet Resolution Merge
- Ehlers Fusion
- HCS Resolution Merge
- Resolution Merge

ENVI:

- CN Spectral Sharpening
- Color Normalized(Brovey)
- Gram-Schmidt
- HSV Sharpening
- PC Spectral Sharpening

Widely used commercial pan-sharpening algorithms

ESRI:

- Brovey
- ESRI
- Gram-Schmid
- IHS
- Simple Mean

FuzeGo:

- UNB Pansharpening

HighView:

- Advanced Global Optimization

Comparison among different pan-sharpening algorithms

Data used for the pan-sharpening:

- **IKONOS**, 2002, Fredericton, Canada (Pan 540 MB, MS 135 MB)
- **QuickBird**, 2007, Beijing, China (Pan 820 MB, MS 205MB)
- **GeoEye-1**, 2009, Hobart, Australia (Pan 816 MB, MS 204 MB)
- **WorldView-2**, 2010, Moncton, Canada (Pan 131 MB, MS 65 MB).

All the images were in 16-bit format. All the MS bands were used in the test.

Pan-sharpening evaluation

- ✓ **Visual Analysis**
- ✓ **Quantitative Analysis**

There is no consensus on quantitative evaluation methods

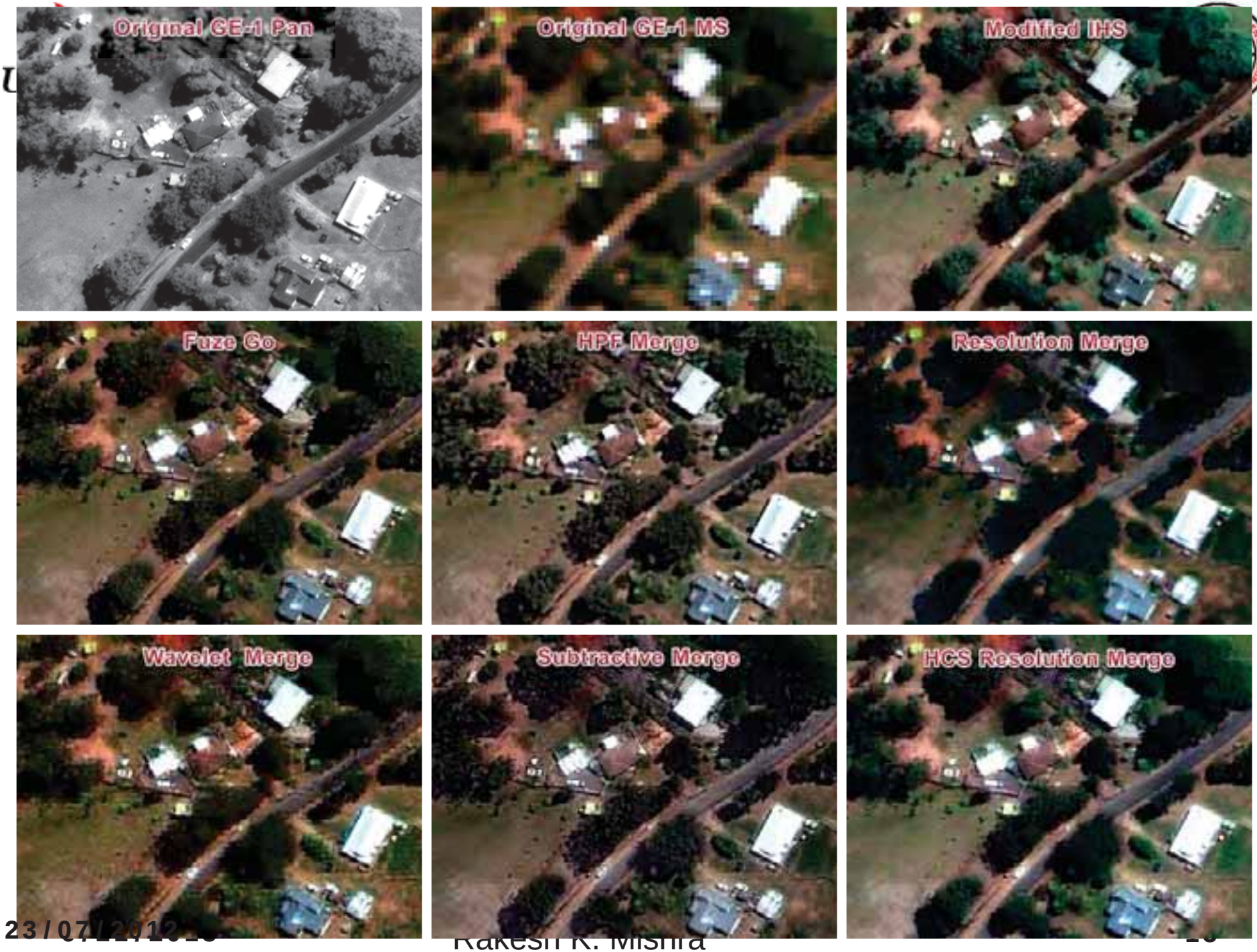
Comparison Results

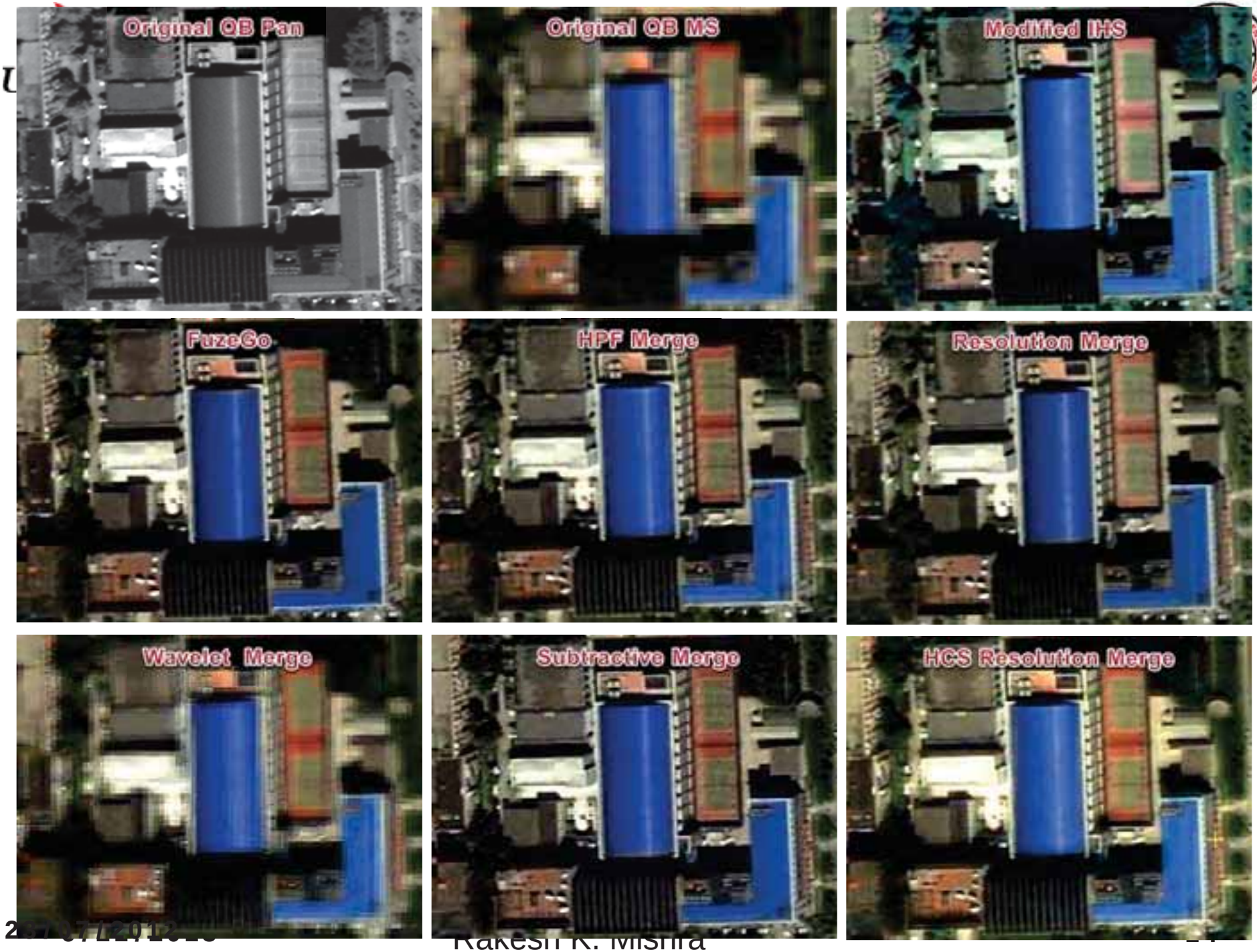
All the images are displayed under the same visualization condition, i.e.

- The same area of the images before and after pan-sharpening are displayed, and
- The same histogram stretching is applied to all the images.

Subtractive Merge

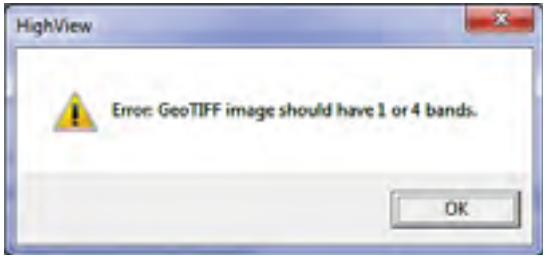
Can not process images with more then 4 bands.


Original GE-1 Pan
Original GE-1 MS
Modified IHS
Fuze Go
HPF Merge
Resolution Merge
Wavelet Merge
Subtractive Merge
HCS Resolution Merge


Original QB Pan
Original QB MS
Modified IHS
FuzeGo
HPF Merge
Resolution Merge
Wavelet Merge
Subtractive Merge
HCS Resolution Merge

Highview Global Optimization

Can not process images with more than 4 bands




Original GE-1 Pan


Original GE-1 MS


ESRI Pansharp


FuzeGo
(without enhancement)


FuzeGo
(with enhancement)

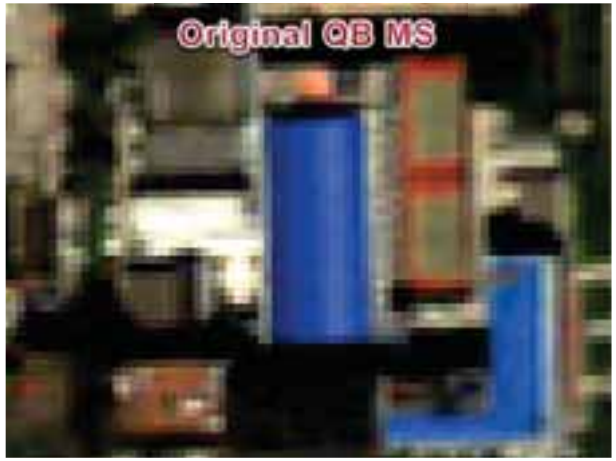

ENVI Gram Schmidt
(Kodak patent)


Highview Global Optimization


ENVI PC Spectral


ENVI Brovey


Original QB Pan


Original QB MS


ESRI Pansharp


FuzeGo
(without enhancement)


FuzeGo
(with enhancement)


ENVI Gram Schmidt
(Kodak patent)


Highview Global Optimization
HighView
Check the image size of Pan and Ms bands. Ratio should be 4:1.
OK


ENVI PC Spectral


ENVI Brovey

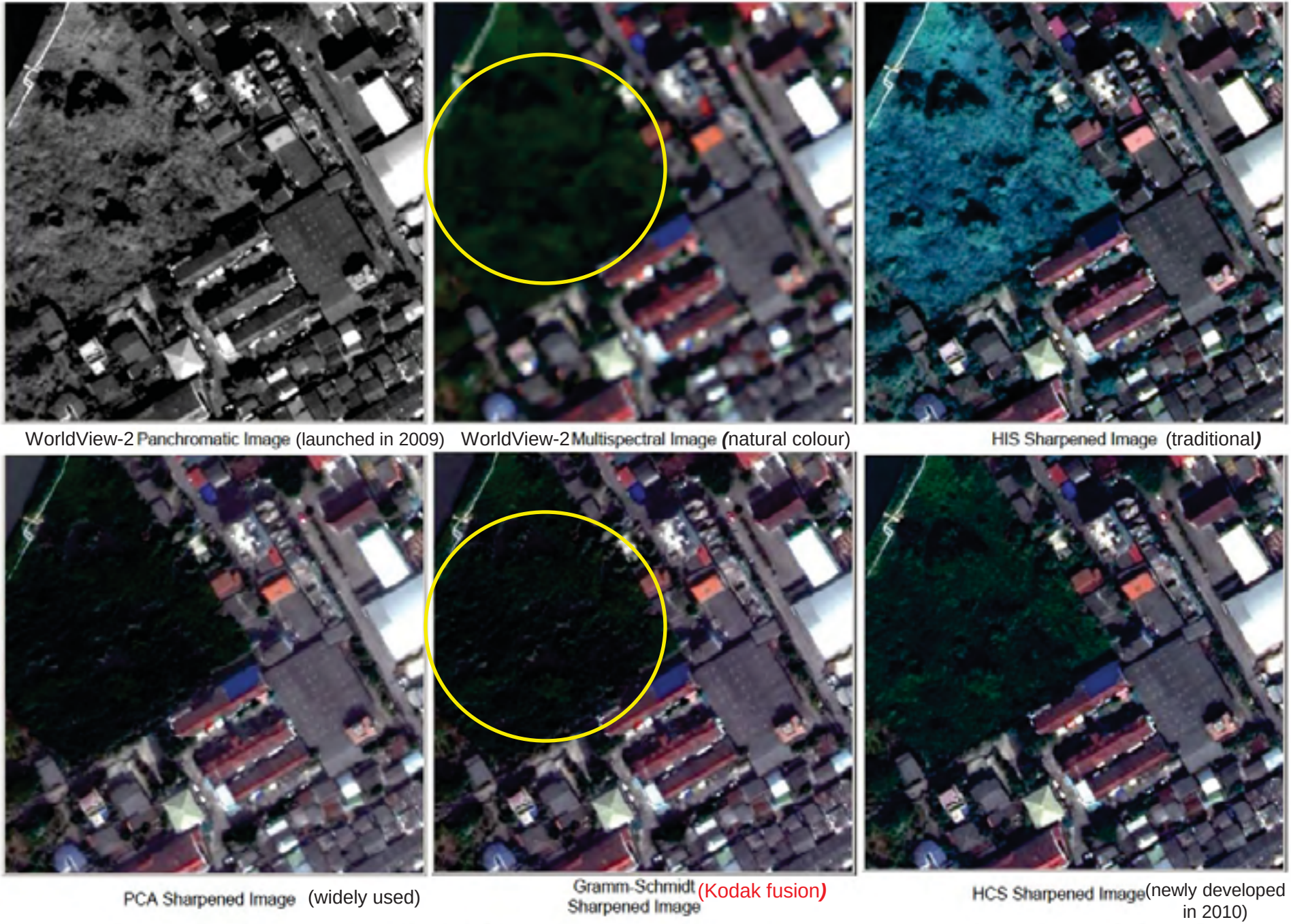
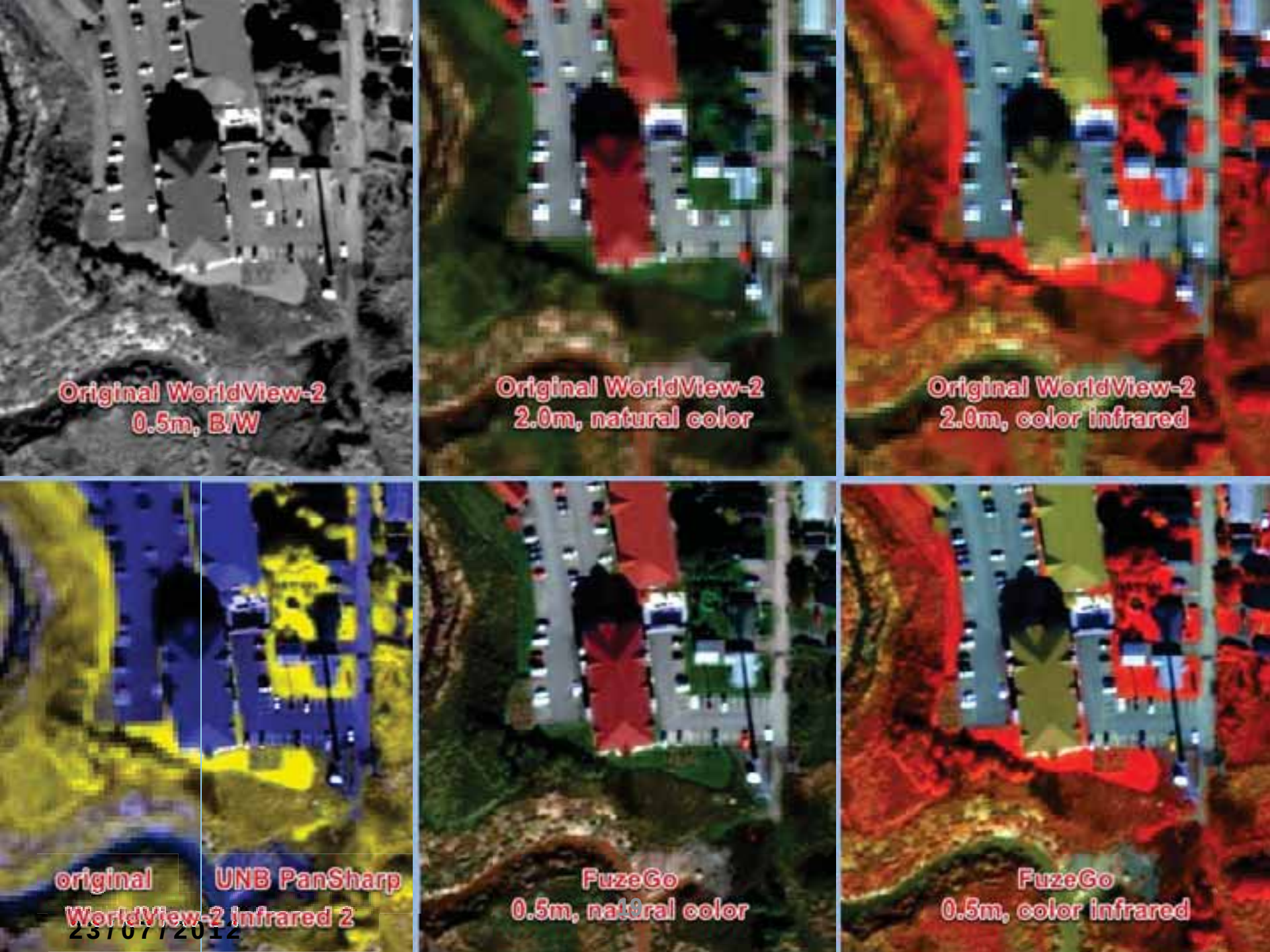


Figure 3. Comparison of performance between the HIS, PCA, GS, and HCS pan-sharpening algorithms for a WV-2 image.

C. Pacwick, M. Deskevich, F. Pacifici, and S. Smallwood (2010): WorldView-2 PanSharpening. ASPRS 2010 Annual Conference, San Diego, California, April 26-30, 2010


Original WorldView-2
0.5m, B/W
Original WorldView-2
2.0m, natural color
Original WorldView-2
2.0m, color infrared
original
UNB PanSharp
WorldView-2 infrared 2
FuzeGo
0.5m, natural color
FuzeGo
0.5m, color infrared

Comparison conclusions

- FuzeGo produces constant best results for all type of sensors and areas.
- Other techniques work well for some images or sensors, but not for others
- The second best technique is Gram-Schmidt (Kodak's patent). But it produces poor results for WorldView-2 images.
- The third best technique is HCS, but still result is not consistent.

Further examples of FuzeGO

IKONOS, July 2000
San Diego, USA

FuzeGo

Original IKONOS Pan and MS images courtesy of Space Imaging Inc. (now GeoEye Inc.)


IKONOS MS 1, 2, 3 in B, G, R, 4m


IKONOS Pan, 1m


IKONOS MS 1, 2, 3 in B, G, R, FuzeGo result 1m


IKONOS MS 2, 3, 4 in B, G, R, 4m


IKONOS Pan, 1m


IKONOS MS 2, 3, 4 in B, G, R, FuzeGo result 1m


IKONOS MS 1, 2, 3 in B, G, R, 4m


IKONOS Pan, 1m


IKONOS MS 1, 2, 3 in B, G, R, FuzeGo result 1m


IKONOS MS 2, 3, 4 in B, G, R, 4m


IKONOS Pan, 1m


IKONOS MS 2, 3, 4 in B, G, R, FuzeGo result 1m

IKONOS MS 1, 2, 3 in B, G, R, 4m (8x enlarged)


IKONOS Pan, 1m

IKONOS MS 1, 2, 3 in B, G, R, FuzeGo result 1m (2x enlarged)

IKONOS MS 2, 3, 4 in B, G, R, 4m (8x enlarged)


IKONOS Pan, 1m

IKONOS MS 2, 3, 4 in B, G, R, FuzeGo result 1m (2x enlarged)

QuickBird, May 2005

Beijing, China

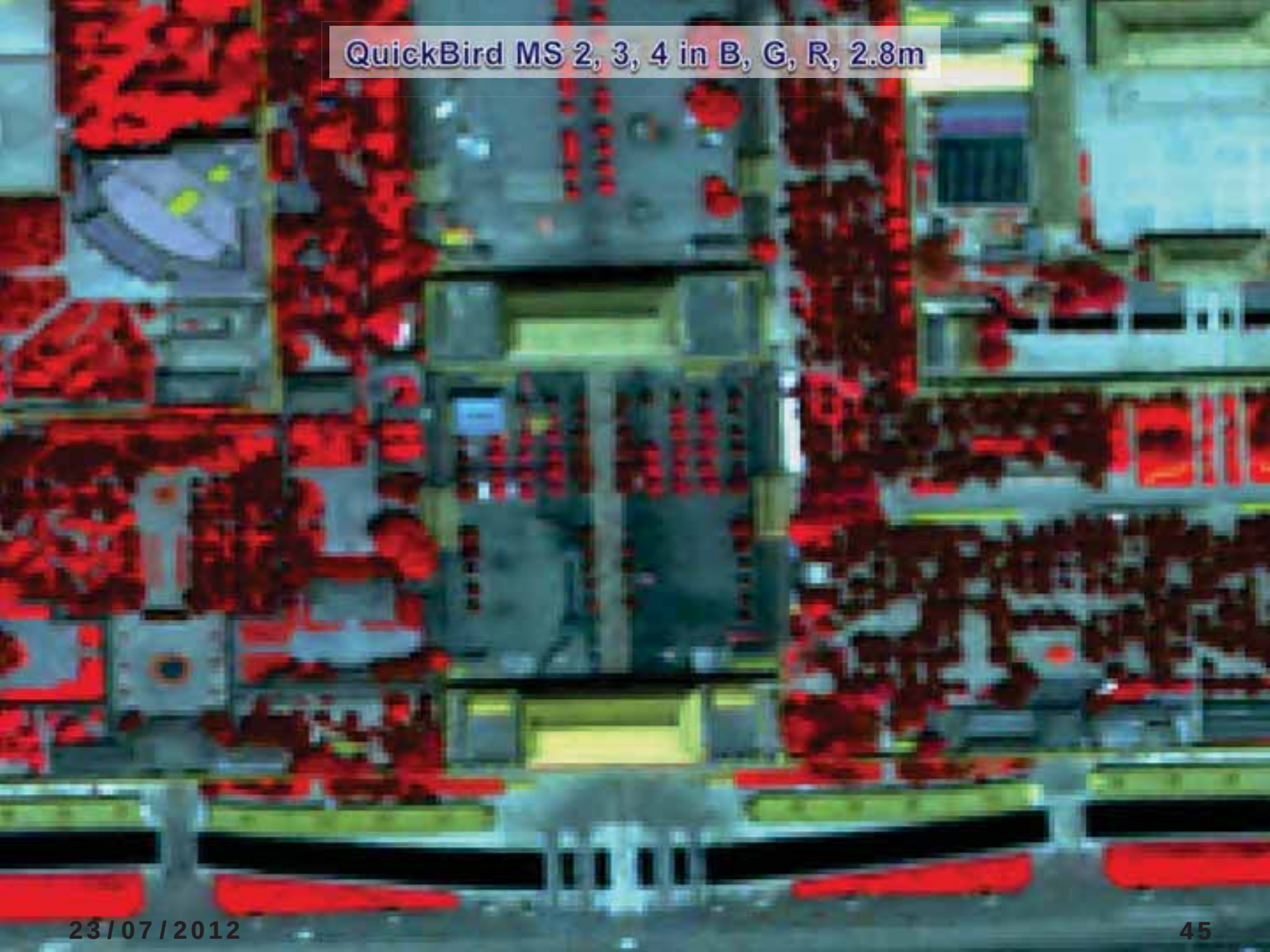
FuzeGo

Original QuickBird Pan and MS images courtesy of DigitalGlobe Inc.

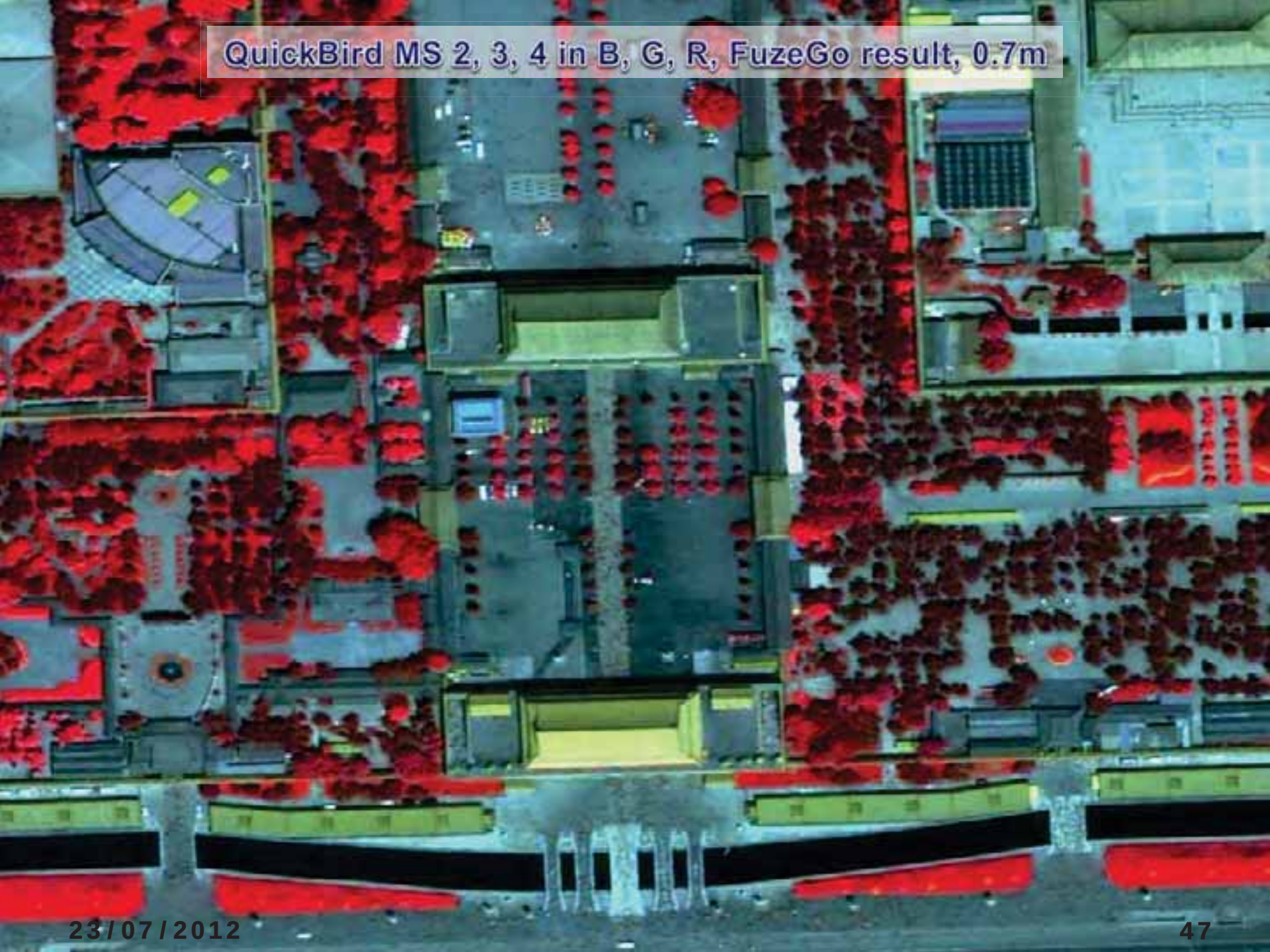

QuickBird MS 1, 2, 3 in B, G, R, 2.8m


QuickBird Pan, 0.7m


QuickBird MS 1, 2, 3 in B, G, R, FuzeGo result, 0.7m


QuickBird MS 2, 3, 4 in B, G, R, 2.8m


QuickBird Pan, 0.7m


QuickBird MS 2, 3, 4 in B, G, R, FuzeGo result, 0.7m


QuickBird MS 1, 2, 3 in B, G, R, 2.8m
(8x enlarged)


QuickBird Pan, 0.7m
(2x enlarged)


QuickBird MS 1, 2, 3 in B, G, R, FuzeGo result, 0.7m
(2x enlarged)


QuickBird MS 1, 2, 3 in B, G, R, FuzeGo result, 0.7m, with enhancement
(2x enlarged)

GeoEye-1, February 2009

Hobart, Australia

FuzeGo

Original GeoEye-1 Pan and MS images courtesy of GeoEye Inc.


GeoEye-1 MS 1, 2, 3 in B, G, R, 2m


GeoEye-1 Pan, 0.5m


GeoEye-1 MS 1, 2, 3 in B, G, R, FuzeGo result 0.5m


GeoEye-1 MS 2, 3, 4 in B, G, R, 2m


GeoEye-1 Pan, 0.5m


GeoEye-1 MS 2, 3, 4 in B, G, R, FuzeGoresult 0.5m

GeoEye-1 satellite, original natural colour, 2m
Launched in 2008


GeoEye-1, original B/W, 0.5m


GeoEye-1, FuzeGo, 0.5m


GeoEye-1, original natural colour, 2m
8x enlarged


GeoEye-1, original B/W, 0.5m
2x enlarged


GeoEye-1, FuzeGo, 0.5m
2x enlarged

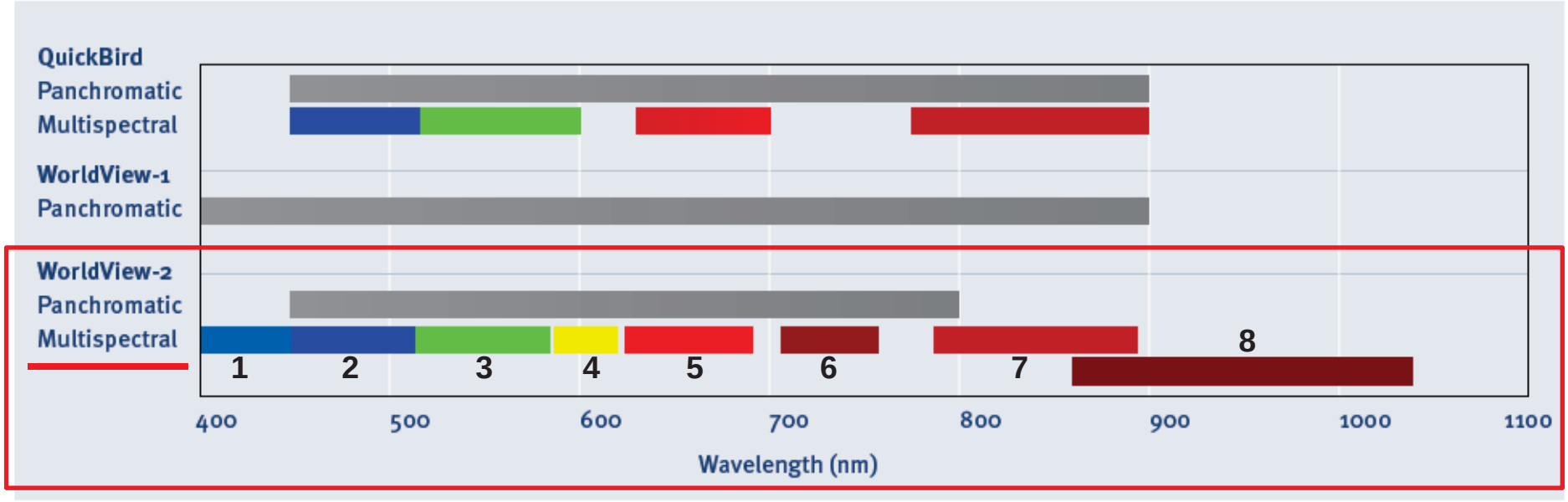
WorldView-2, July 2010
Moncton, Canada

FuzeGo

Original WorlView-2 Pan and MS images courtesy of DigitalGlobe Inc.

The 8 Spectral Bands of WorldView-2

WorldView-2 is the first commercial high-resolution satellite to provide 8 spectral sensors in the visible to near-infrared range. Each sensor is narrowly focused on a particular range of the electromagnetic spectrum that is sensitive to a particular feature on the ground, or a property of the atmosphere. Together they are designed to improve the segmentation and classification of land and aquatic features beyond any other space-based remote sensing platform.

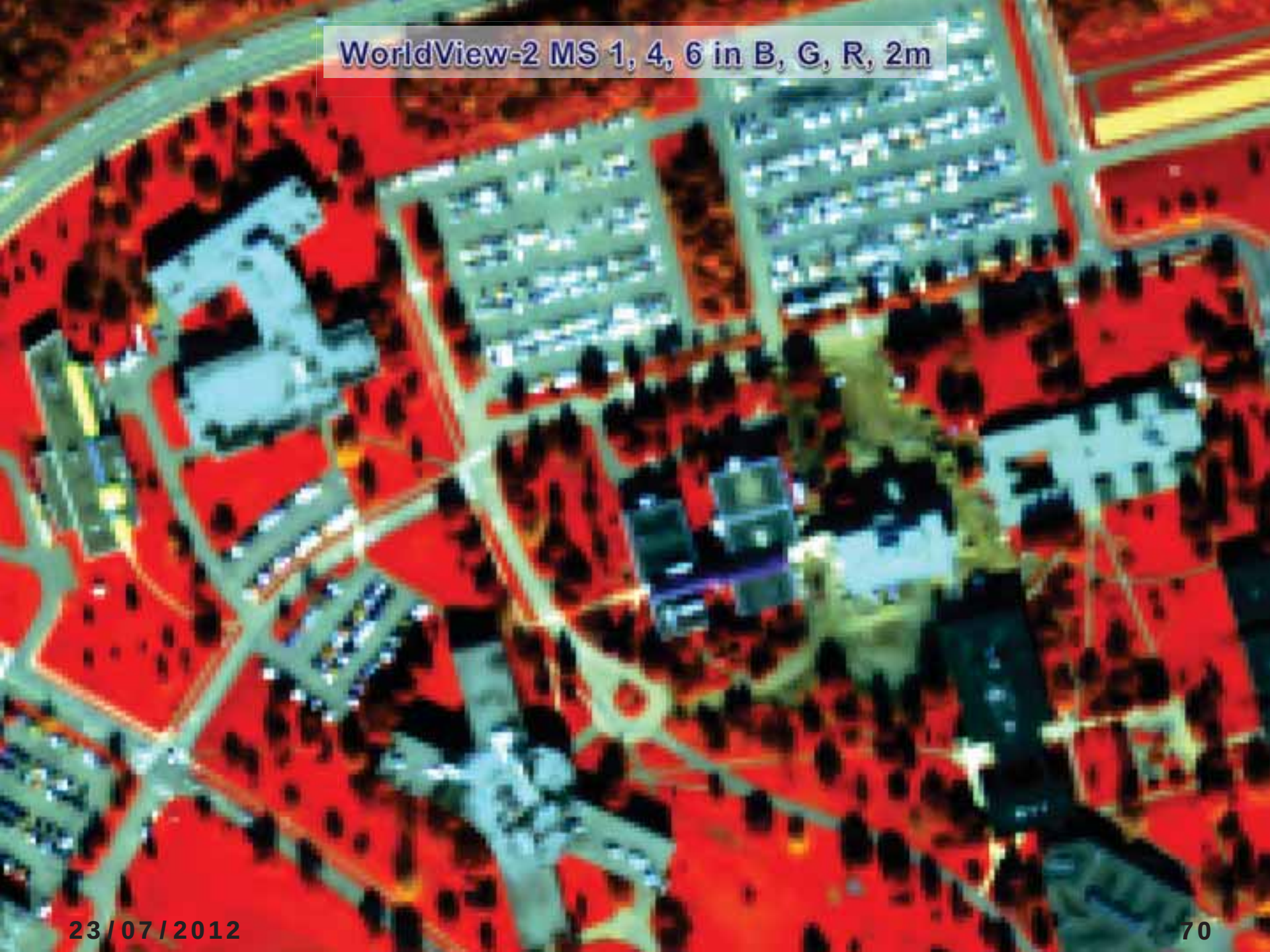


www.DigitalGlobe.com


WorldView-2 MS 2, 3, 5 in B, G, R, 2m

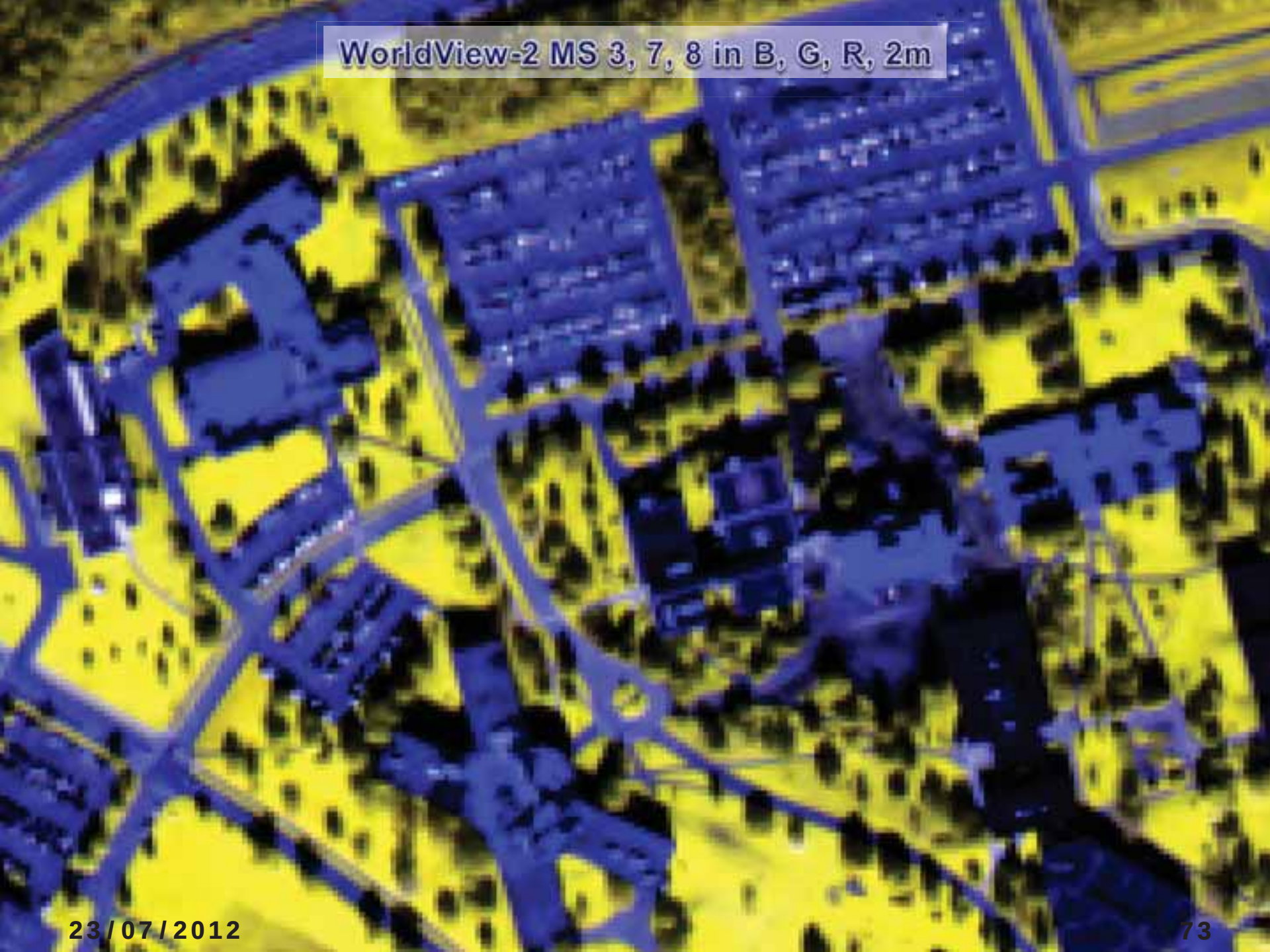

WorldView-2 Pan, 0.5m


WorldView-2 MS 2, 3, 5 in B, G, R, FuzeGo result 0.5m

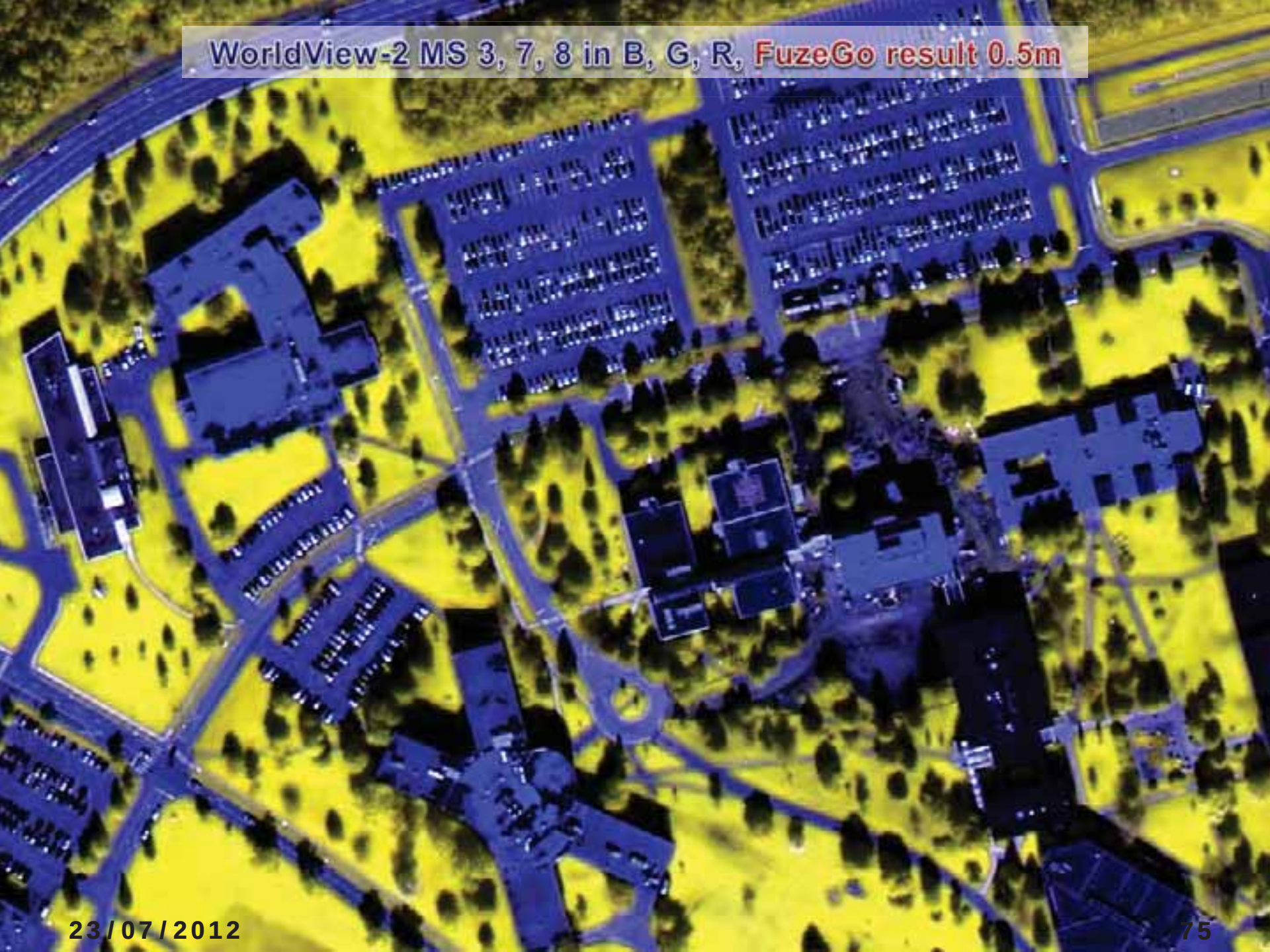

WorldView-2 MS 1, 4, 6 in B, G, R, 2m


WorldView-2 Pan, 0.5m

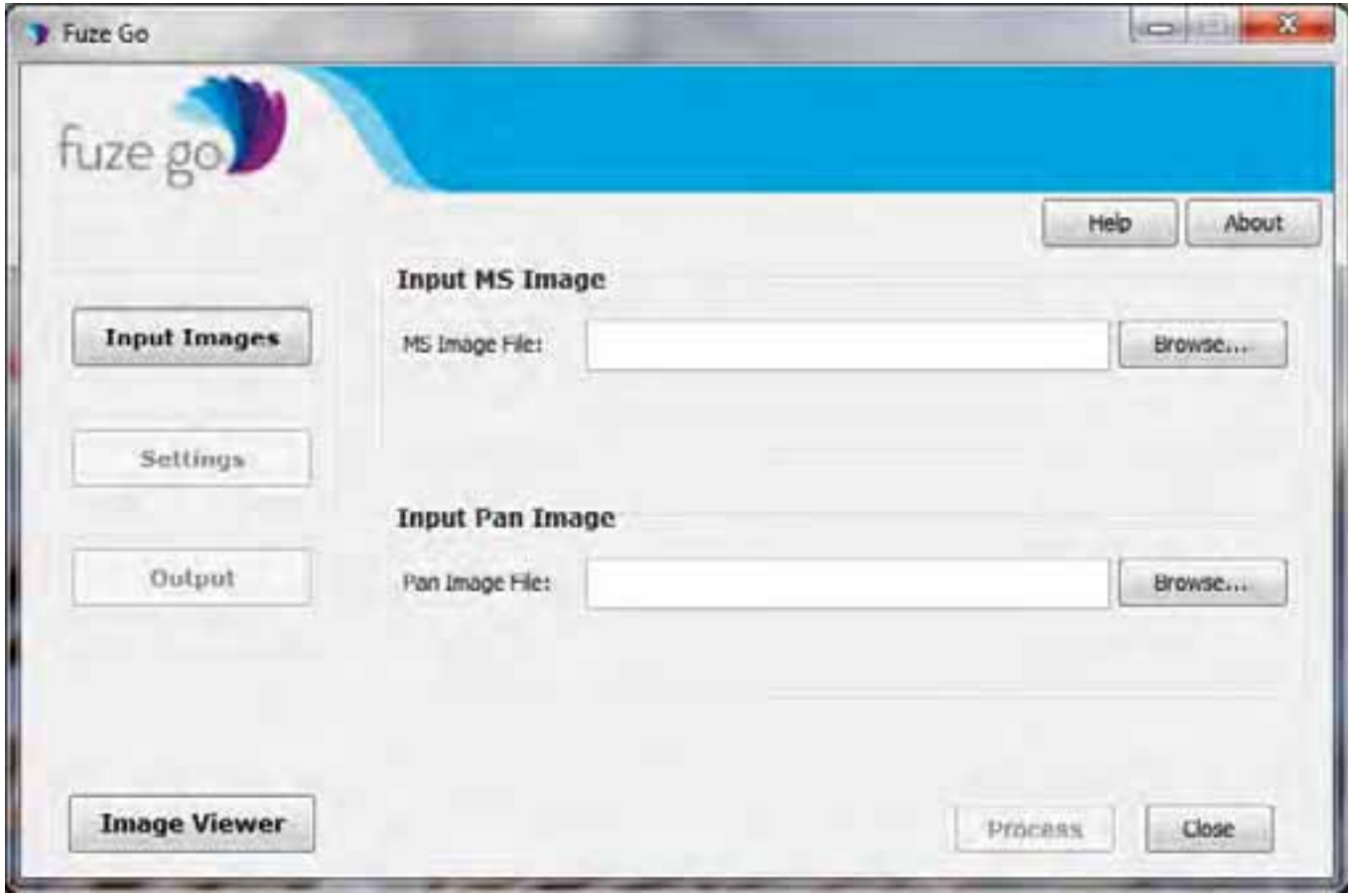

WorldView-2 MS 1, 4, 6 in B, G, R, FuzeGo result 0.5m


WorldView-2 MS 3, 7, 8 in B, G, R, 2m


WorldView-2 Pan, 0.5m

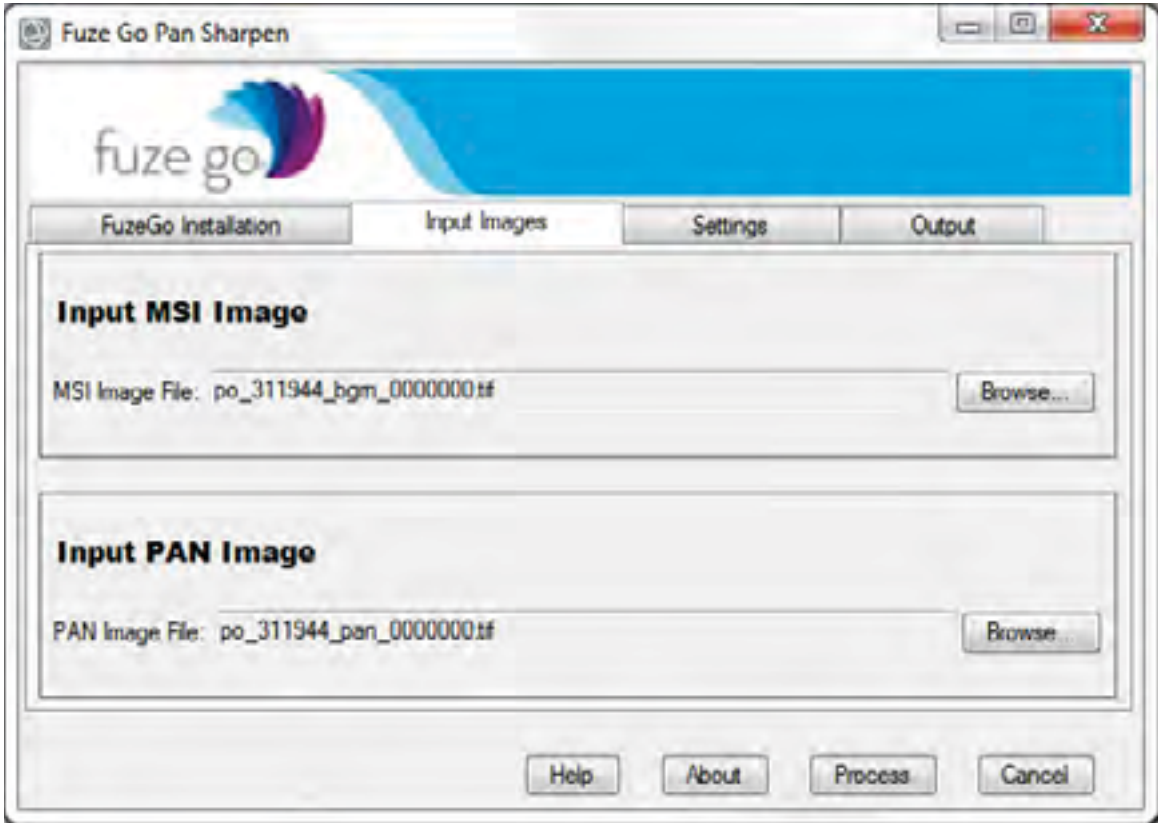

WorldView-2 MS 3, 7, 8 in B, G, R, FuzeGo result 0.5m

FuzeGo Software



http://www.fuzego.com/

FuzeGo in ENVI 5.1 Beta



Conclusion

- ✓ FuzeGo achieves constant good fusion results regardless of the differences in sensors, areas and seasons.
- ✓ Fully automatic
- ✓ FuzeGo achieves:
  - maximum detail increasing,
  - minimum colour distortion, and
  - optimal colour and feature integration.
- ✓ UNB-Pansharp has been widely recognized by industry

Acknowledgments

- DigitalGloble Inc. and GeoEye Inc. provided the original Pan and MS images.
- The comparative research was conducted at the University of New Brunswick, Canada.
- GEOIDE MDF program provided the funding for the research.

Thank you !

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