

A Preliminary Study on Imaging Time Difference Among Bands of Worldview-2 and Its Potential Applications

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Worldview-2

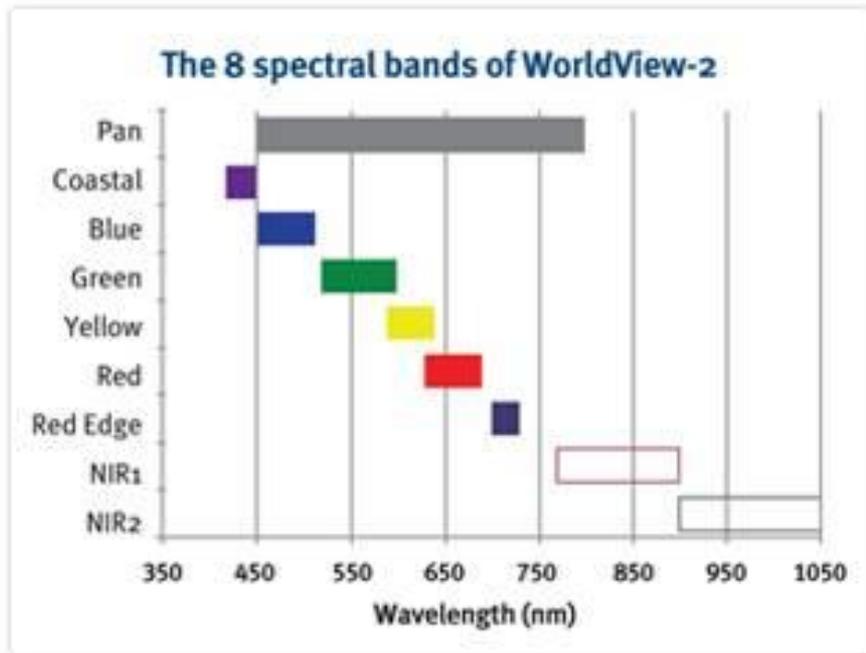
Launch Date: October 8, 2009, from Vandenberg AFB

Orbit: circular sun-synchronous orbit 100.2 minutes, 770 km
a descending nodal crossing time of approximately 10:30 a.m.

Bands : 11-bit data in 9 bands: panchromatic, coastal, blue, green, yellow, red, red edge, NIR1, and NIR2.

GSD: nominal GSD 0.46 m (panchromatic) 1.84 m (multispectral)

Swath: The nominal swath 16.4 km.



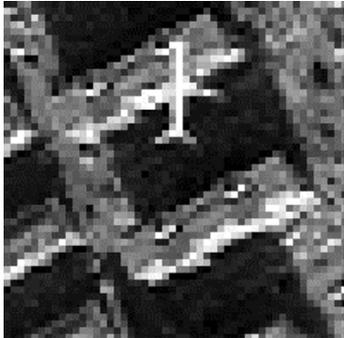
A Worldview-2 Image



JAN 03, 2010, Panchromatic, Hongqiao Airport, Shanghai, China

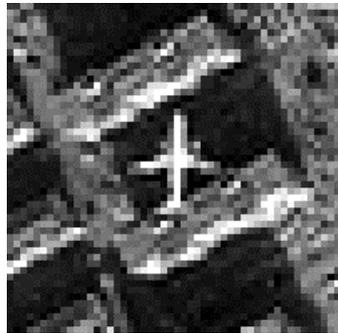
An Airplane's Image

B1



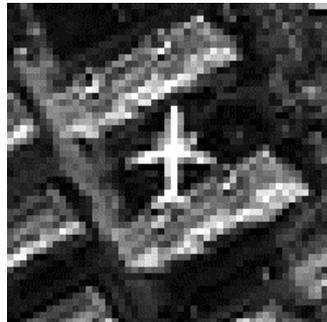
Coastal Blue

B2



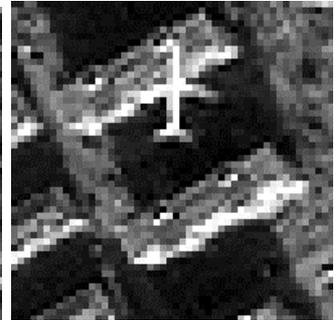
Blue

B3



Green

B4



Yellow

B5



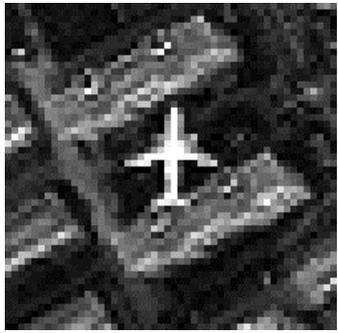
Red

B6



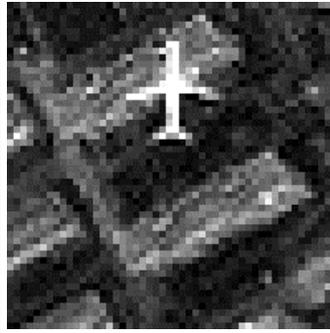
Red-Edge

B7



NIR1

B8



NIR2

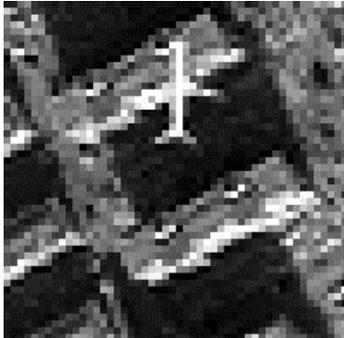
PAN



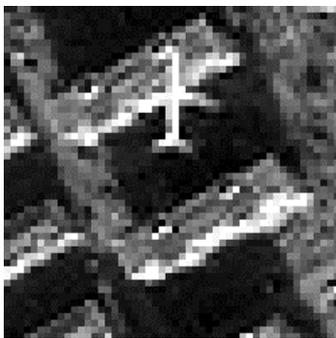
Panchromatic

An Airplane's Image

B1



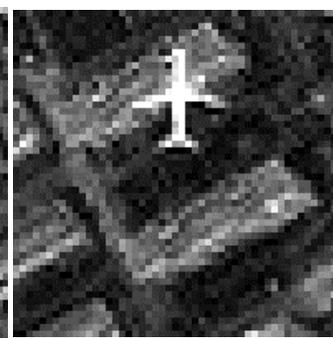
B4



B6

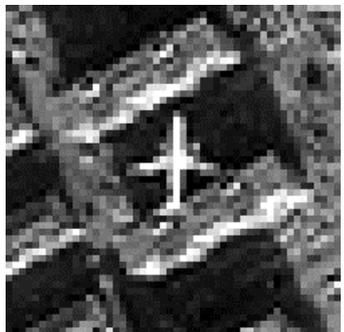


B8



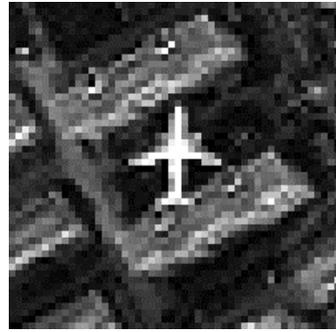
Coastal Blue

B2



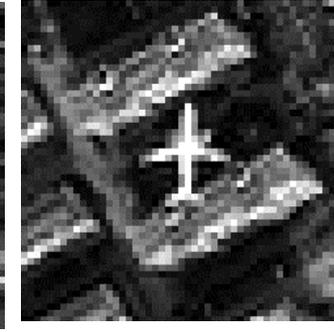
Yellow

B3



Red-Edge

B5



NIR2

B7



Panchromatic

Blue

Green

Red

NIR1

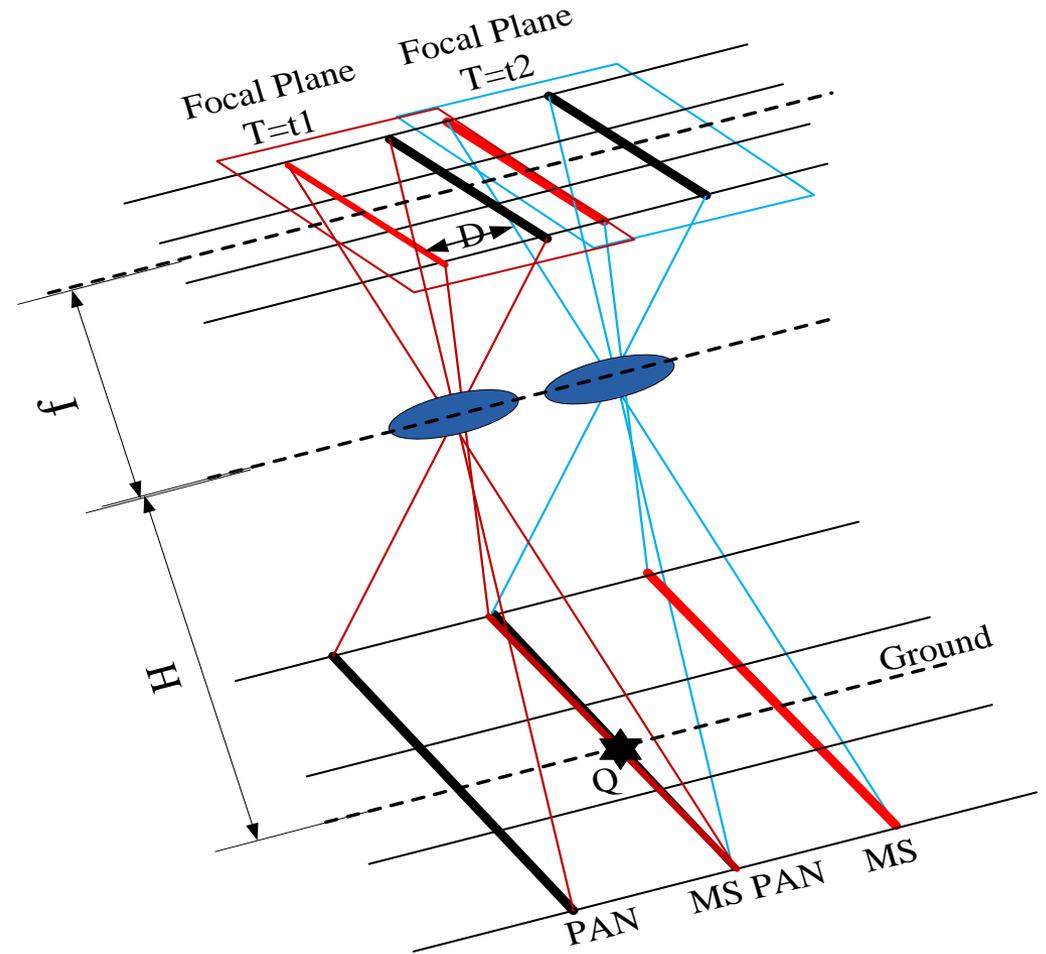
Reason

Different bands have different imaging time for the same point on the earth surface.

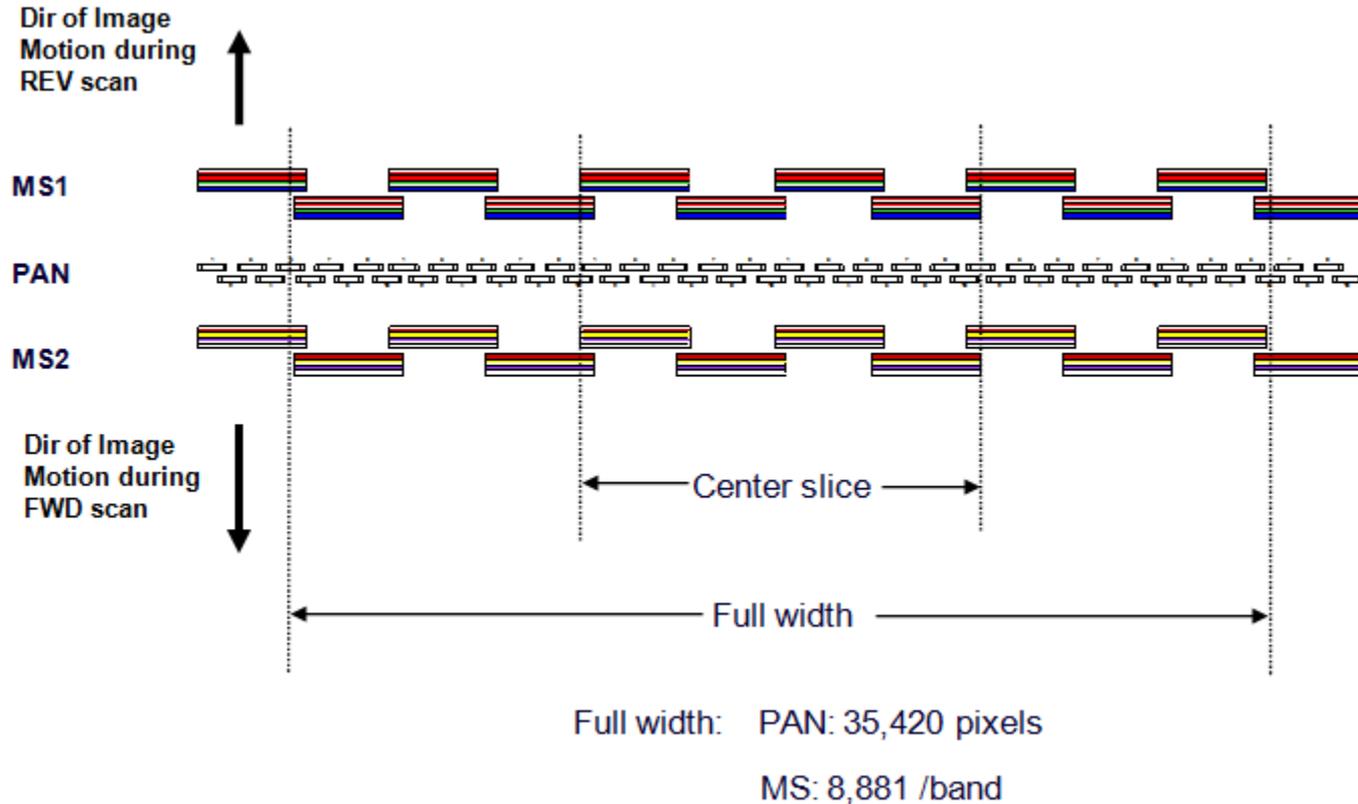
Moving objects have different image in the same set of satellite image.

$$\Delta t = D * H / (f * GSD * LR)$$

LR is the line rate



Worldview-2 Focal Plane Layout



From "Radiometric Use of WorldView-2 Imagery (DigitalGlobe)"

Time difference?

For Quickbird L1B data, D, H, f, GSD, LR are all ready in Geo and other files

For Worldview-2 L1B data, H, f, GSD, LR are ready, but D is zero in Geo file. We have to estimate the imaging time difference of different bands.

Method1: Using the landing airplane near Hongqiao Airport

If we know the speed of the plane, and the moving distance between bands, the time difference can be estimated.

Method2: Supposing D of Worldview-2 to be the same of Quickbird

Time difference estimation

Method1



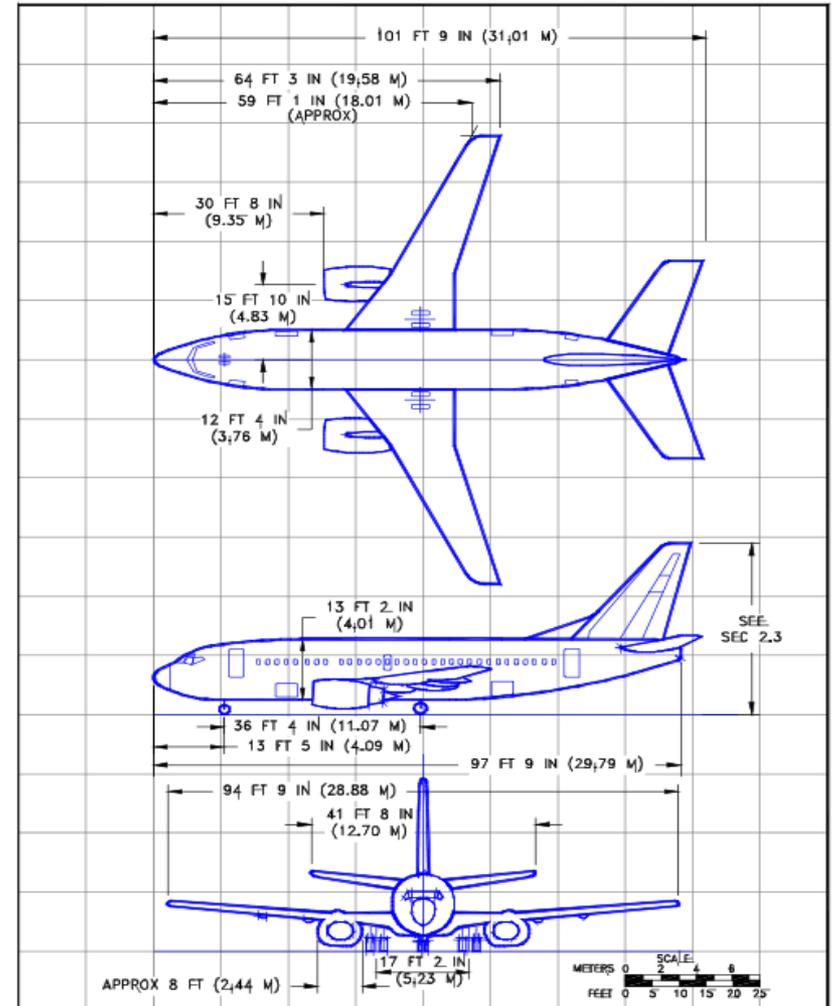
Airplane model recognition:

Measuring the dimensions of the airplane, comparing to all models from Boeing and Airbus.

It is a Boeing 737-400

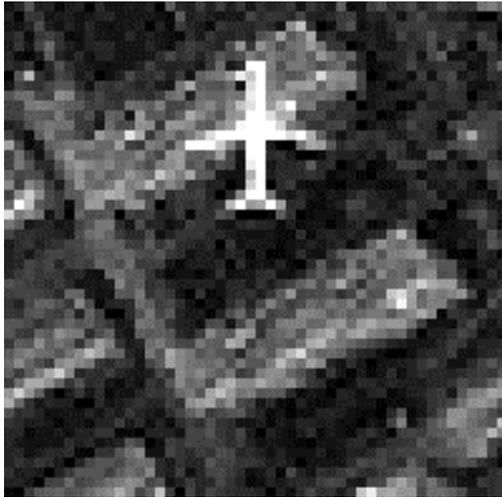
Landing speed estimation:

From flight manual, the land speed at this place: 145-165knots, about 75-85m/s



Time difference estimation

Method 1



NIR2



PAN



NIR1

Moving distance measuring:

NIR2 – PAN : 9m

PAN – NIR1 : 9m

NIR2 – NIR1 : 17.5m

Time Difference: $17.5/80 = 0.22s$ for NIR1 – NIR2

Time difference estimation

Method 2

For worldview-2:

$f = 13.3\text{m}$, $H = 770\text{km}$, $\text{GSD} = 1.84\text{m (MS)}$, $\text{LR} = 5000$

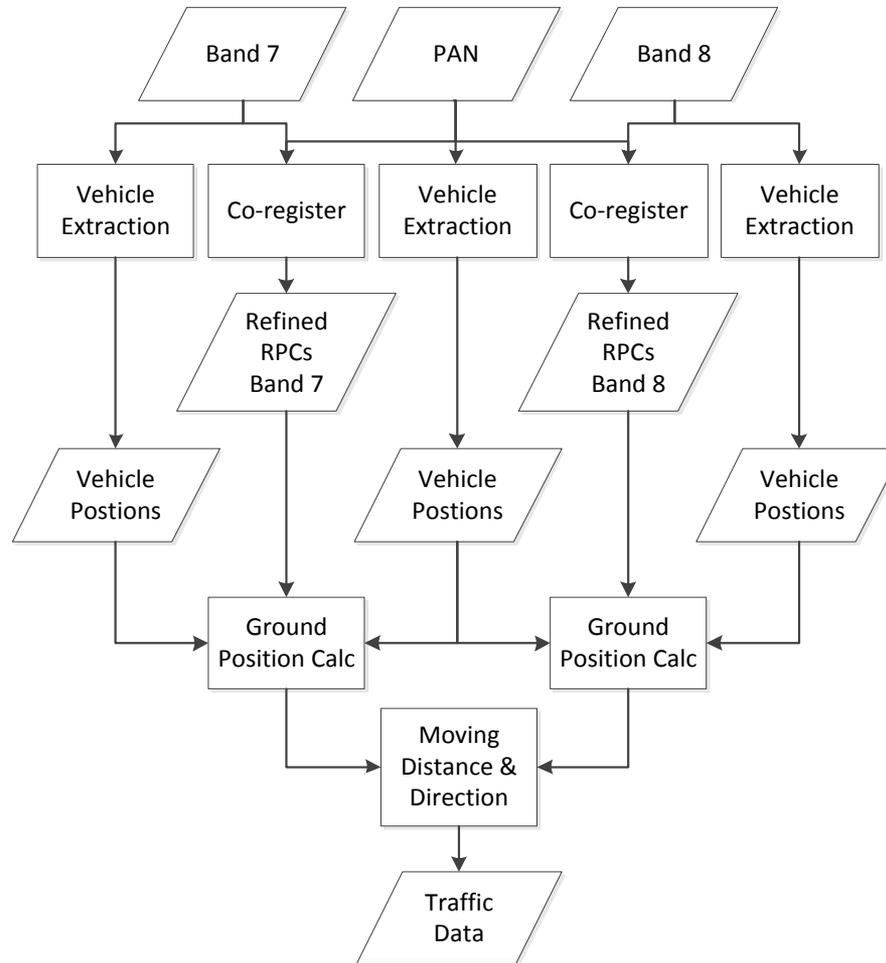
if we suppose D of two groups of MS bands is the same of Quickbird, that is 35.14mm , then the time difference between two groups of MS bands:

$$\Delta t = D * H / (f * \text{GSD} * \text{LR}) = 35.14 * 770000000 / (13300 * 1840 * 5000) = 0.2211\text{s}$$

Of course, Δt varies according to the actual position and attitude of the satellite, this is only a rough value. But it is quite in accordance with the value we estimated by using method 1.

Applications:

1. Speed estimation



Algorithm

Application: Speed estimation



Part of the same image
Vehicles in Express highway

Application: Speed estimation

| No | NIR2 | | NIR1 | | PAN | | Estimated Speed(km/h) |
|----|--------|-----|--------|-----|--------|------|-----------------------|
| | column | Row | column | row | column | row | |
| 1 | 778 | 496 | 783 | 496 | 3077 | 1980 | 126.6545 |
| 2 | 816 | 495 | 819 | 495 | 3226 | 1978 | 72.32727 |
| 3 | 821 | 498 | 824 | 498 | 3245 | 1989 | 76.58182 |
| 4 | 825 | 500 | 829 | 500 | 3263 | 1997 | 105.3818 |
| 5 | 861 | 501 | 866 | 501 | 3407 | 2003 | 123.7091 |
| 6 | 876 | 498 | 879 | 498 | 3467 | 1991 | 69.70909 |
| 7 | 927 | 501 | 930 | 500 | 3674 | 2000 | 73.30909 |
| 8 | 989 | 506 | 993 | 506 | 3709 | 2012 | 101.7818 |
| 9 | 936 | 503 | 941 | 503 | 3921 | 2027 | 123.0545 |
| 10 | 1006 | 507 | 1010 | 507 | 3988 | 2026 | 100.4727 |
| 11 | 1010 | 505 | 1012 | 505 | 4001 | 2017 | 43.85455 |
| 12 | 1009 | 509 | 1014 | 509 | 4001 | 2033 | 131.5636 |
| 13 | 1049 | 511 | 1053 | 511 | 4161 | 2040 | 97.52727 |
| 14 | 1087 | 521 | 1083 | 520 | 4295 | 2080 | 105.7091 |
| 15 | 1079 | 519 | 1075 | 519 | 4261 | 2074 | 102.1091 |
| 16 | 1069 | 523 | 1066 | 523 | 4224 | 2090 | 69.05455 |
| 17 | 1052 | 520 | 1048 | 520 | 4155 | 2080 | 105.0545 |
| 18 | 1010 | 516 | 1005 | 515 | 3983 | 2061 | 126.3273 |
| 19 | 983 | 512 | 979 | 516 | 3877 | 2065 | 94.58182 |
| 20 | 977 | 519 | 973 | 519 | 3849 | 2072 | 99.16364 |
| 21 | 914 | 514 | 910 | 513 | 3601 | 2051 | 105.0545 |
| 22 | 875 | 508 | 870 | 508 | 3448 | 2031 | 132.5455 |
| 23 | 805 | 505 | 800 | 505 | 3164 | 2022 | 134.1818 |
| 24 | 799 | 508 | 796 | 508 | 3147 | 2030 | 72.98182 |
| 25 | 784 | 509 | 779 | 508 | 3084 | 2035 | 129.2727 |
| 26 | 783 | 505 | 779 | 505 | 3080 | 2018 | 93.92727 |

Vehicles' speed table

Applications:

2. Instant Traffic Animation



Blue



PAN



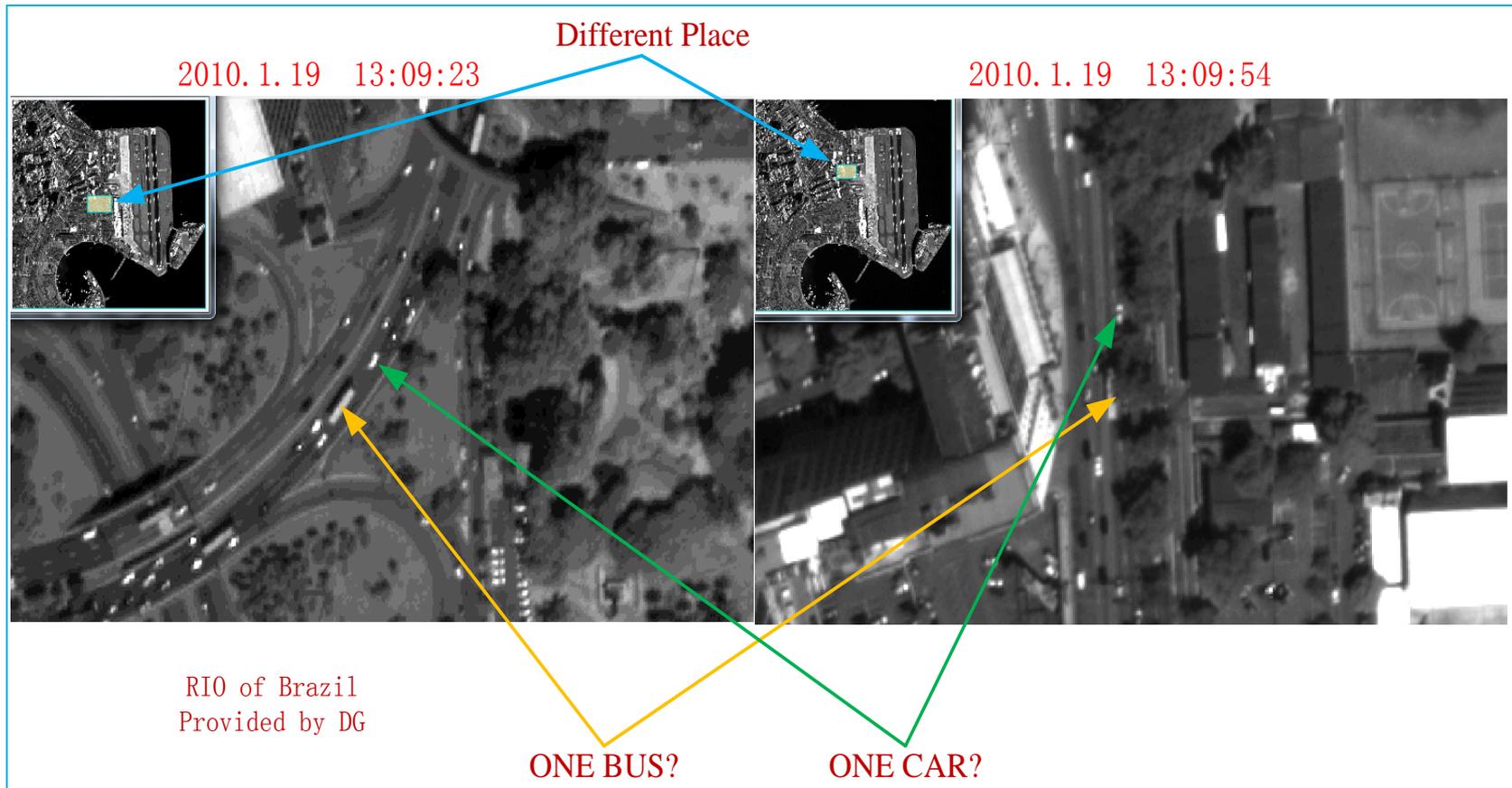
Coastal Blue

Three Bands play
one by one in short
time



Instant traffic Animation

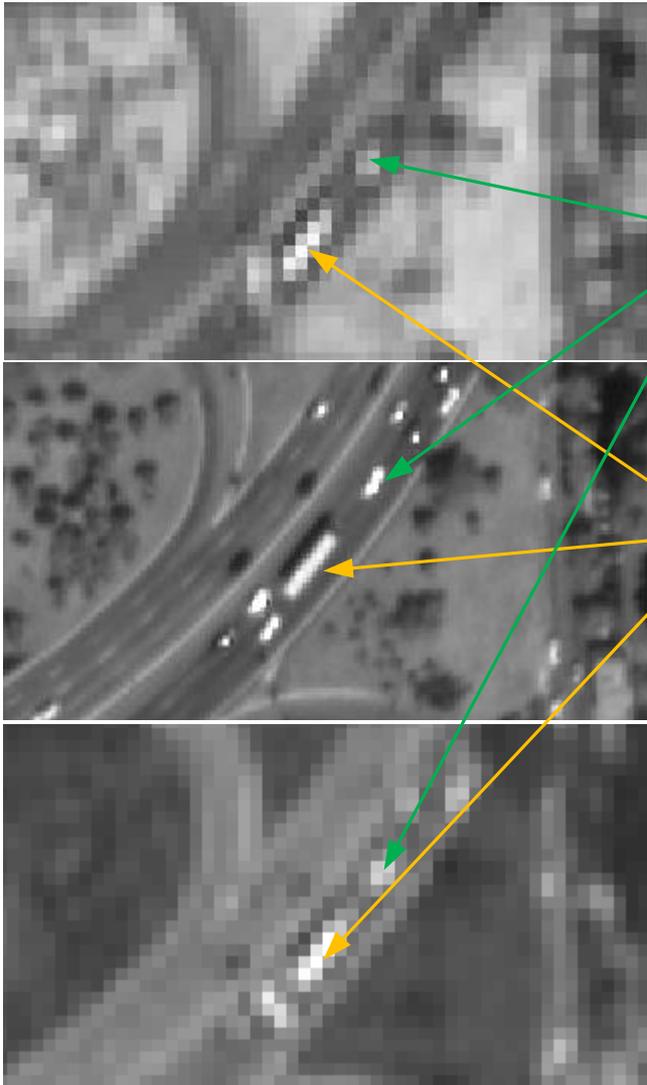
Applications: 3. Tracking



Usually It's Impossible to verify if it is the same vehicle

Applications: Tracking

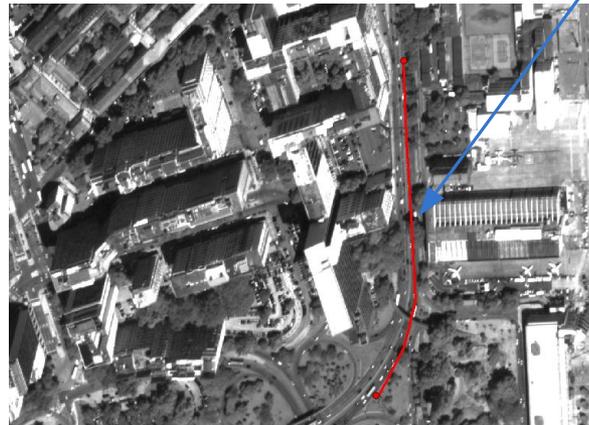
Instant Speed Estimation
Travel Distance Estimation



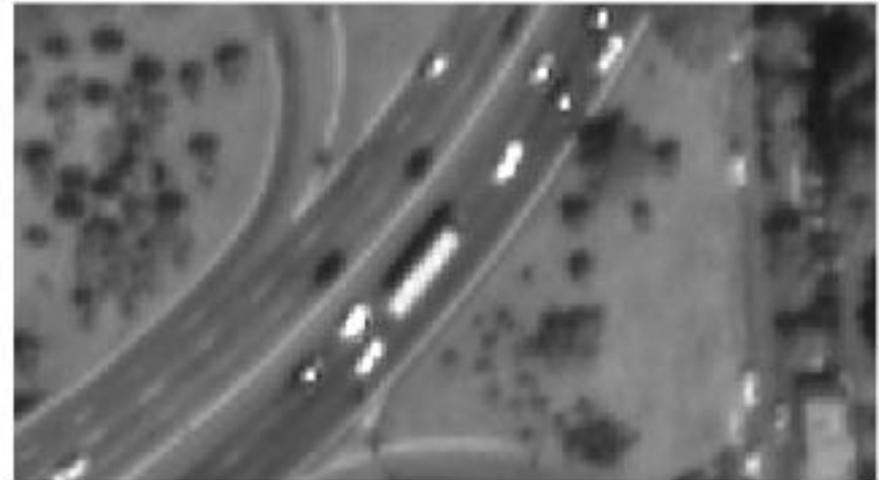
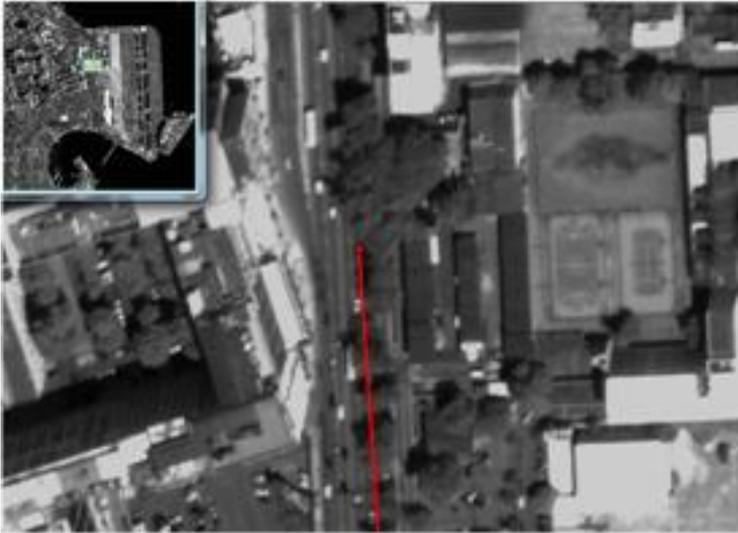
Speed Estimation:
12.2m/s

Speed Estimation:
12.2m/s

Travel Distance in 32s
Estimation: 390m



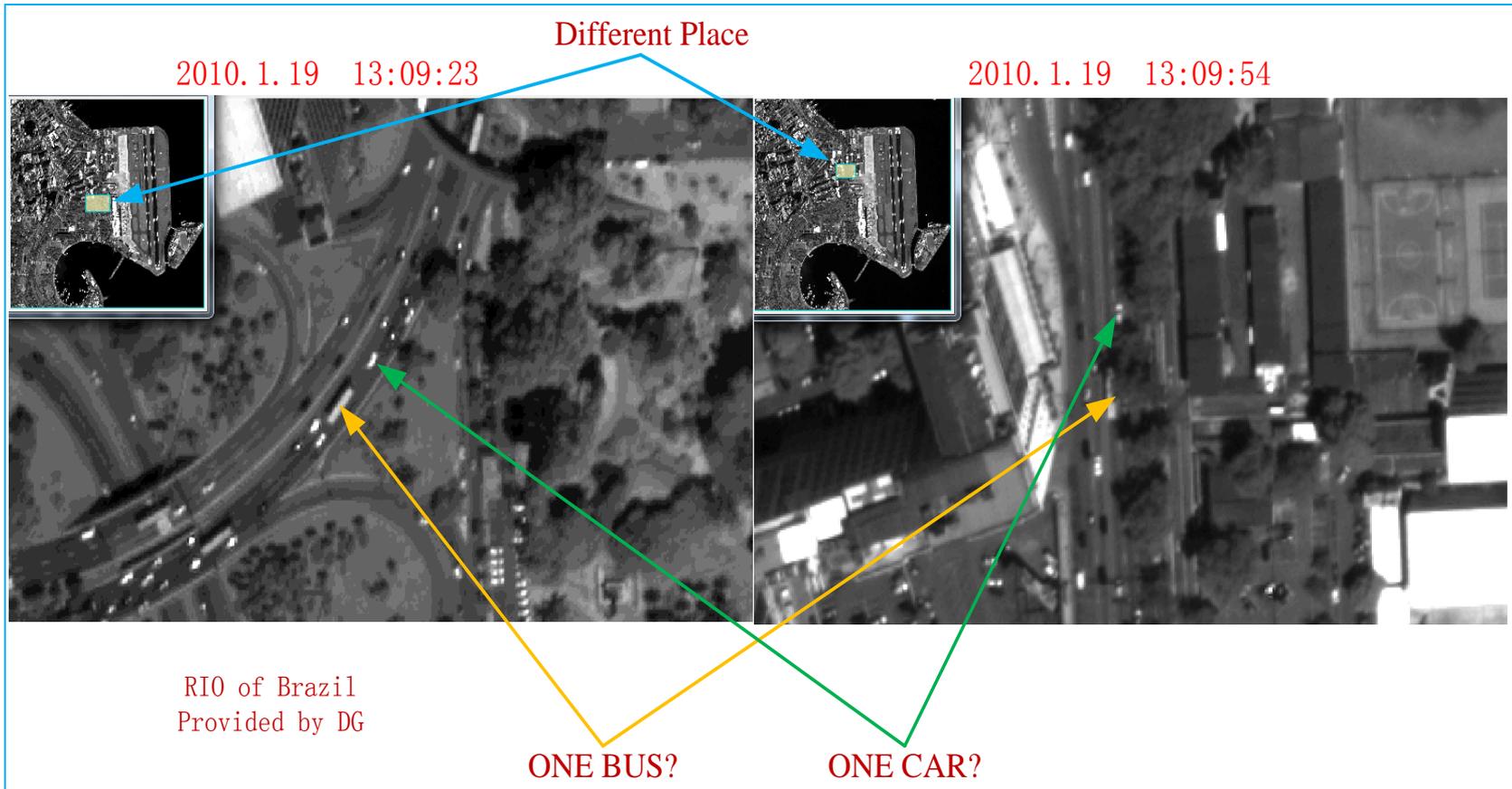
Applications: Tracking



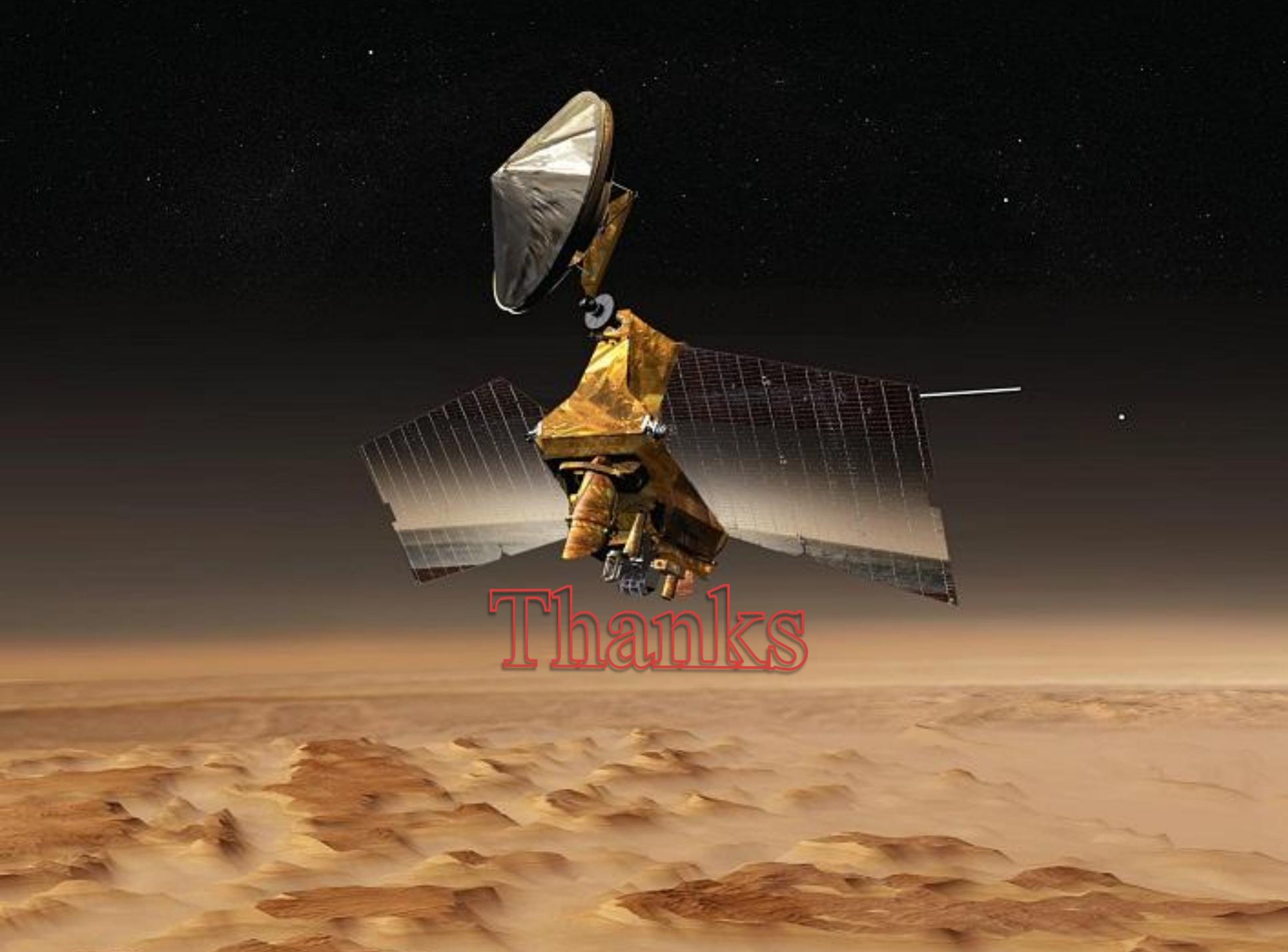
Size Comparison between the original
bus&car and buses & car around the end
point (Exclude opposite buses & cars)

Size Comparison Around Endpoint

Applications: Tracking



Conclusion: Yes, the same bus and the same car



Thanks