

Satellite Imagery and the Libyan Conflict

***A report prepared for the International Commission of
Inquiry on Libya, Office of The High Commissioner for
Human Rights***

February 23, 2012 – Version 2.0

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UNOSAT

PREFACE: The UN Institute for Training and Research / Operational Satellite Applications Programme (UNITAR / UNOSAT) is a technology-intensive effort that specialises in satellite imagery analysis. UNOSAT acts as a centre of excellence for the UN system and its member states to provide solutions and assistance that help make a difference in critical areas such as humanitarian relief, human security, and strategic territorial and development planning. UNOSAT carries out its activities based on the UNITAR mandate in the area of applied research and advanced knowledge development.

UNOSAT supported the UN Office of The High Commissioner for Human Rights by performing detailed satellite imagery analysis in response to multiple specific requests from the International Commission of Inquiry on Libya (CoI). Specifically, UNOSAT analysed dozens of high-resolution commercial satellite images acquired primarily between 4 January and 22 October 2011, with additional archival imagery from 2009 and 2010 utilized as needed. Sources of imagery analysed by UNOSAT included the GeoEye-1, QuickBird, WorldView-1, and WorldView-2 satellites operated by the GeoEye and DigitalGlobe corporations.

In response to requests from the CoI UNOSAT staff developed a series of analytical information products on multiple areas and issues of concern. Specifically, UNOSAT sought to provide input to investigations carried out by the CoI on multiple NATO airstrikes, actions of pro-Gadaffi forces, and actions of anti-Gadaffi forces during the 2011 conflict in Libya. The results of these analyses are detailed on the following pages and summarized as:

Destroyed Buildings and Possible Military Activity in Bani Walid: UNOSAT analysed two factory areas, a medical school complex, and a civilian home to document destruction of those locations resulting from NATO airstrikes and to determine if any military activity was visible in imagery spanning eleven dates between 9 March and 5 October 2011. Destruction was easily visible in available post-strike imagery for one of the factories and civilian home, while no such imagery was acquired by UNOSAT for the other factory or for the medical school complex. Likely significant military activity was apparent especially in proximity to one of the factories and the medical complex, especially on 22 May 2011, in the form of light trucks and possible light armored vehicles.

Destruction of the Compound of Major General El-Khweldi El-Hamedi: UNOSAT reviewed pre- and post-strike imagery from 27 May and 15 July 2011 of the area surrounding the home of El-Hamedi to document destruction from an airstrike and to determine if military activity was visible. Destruction was readily visible by 15 July and several likely armored vehicles were located more than two kilometres away on 27 May while an additional armored vehicle is present in the compound itself on 15 July.

Damage Assessment and Destruction in Sirte: UNOSAT conducted an analysis of destruction and other notable details for the city of Sirte and surrounding areas using imagery acquired on multiple dates between 16 September and 22 October 2011. While a few areas of damage were visible by 16 September much greater damage and destruction were visible by 22 October, including debris, collapsed buildings, numerous flooded areas, and the aftermath of airstrikes on civilian homes and vehicles. Vehicle concentrations, both destroyed and intact, resulting from the capture of Gadaffi as well as possible and confirmed groups of body bags are visible in imagery from 21 and 22 October.

Destroyed Building in Tripoli: UNOSAT conducted an analysis of the effects of an airstrike on a building in Tripoli using pre- and post-strike imagery from multiple dates. The destruction of the building in question between 10 June and 21 August 2011 is readily apparent.

Destruction of the Mosque at Martyrs' Square in Zawiyah: UNOSAT documented the destruction of the mosque in Martyr's Square in Zawiyah using imagery collected between 8 March and 20 March 2011. Tanks are visible prior to the destruction of the mosque while heavy construction equipment and numerous light trucks are visible in the imagery proximate to the razed mosque following its destruction.

Destroyed Housing in the Area of Al Huwayjat: UNOSAT documented the destruction of civilian homes and other structures in Al Huwayjat, south of Ziltan, as a result of an airstrike. Imagery acquired on 6 August and 9 August 2011 clearly indicated the destruction of four homes and associated outbuildings, as well as the destruction of a block of apartment towers, in the period between those dates. In addition, significant military equipment was located, including possible multiple rocket launcher systems in firing position and a large convoy of light trucks.

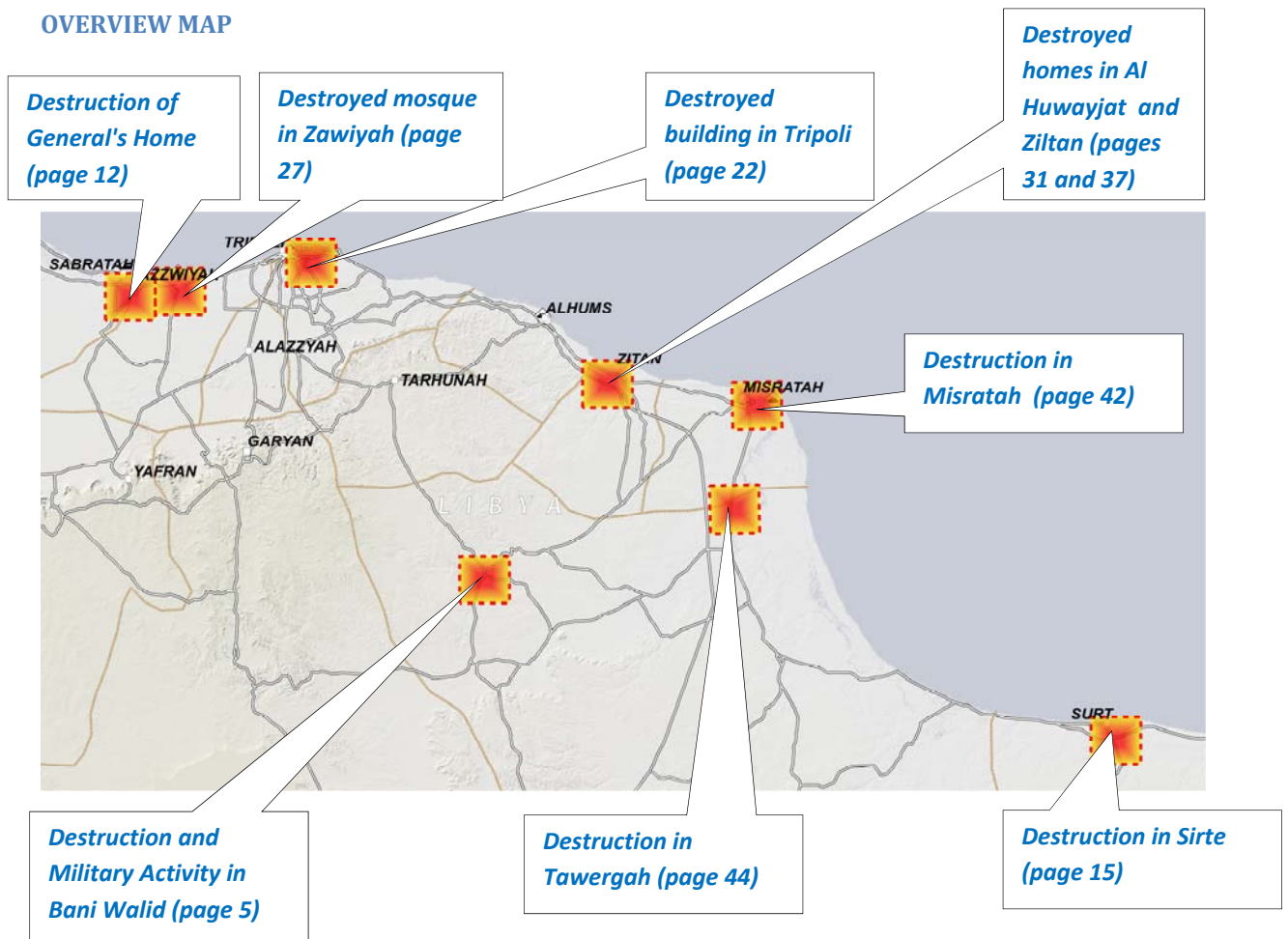
Destroyed Building Near Ziltan: UNOSAT acquired and analysed imagery from 3 August and 6 August 2011 to document the destruction of a civilian home near Ziltan between those dates. Review of the imagery indicated little, if any, proximate military presence, with a nearby grouping of light trucks occurring in an area which had hosted similar groupings of vehicles as far back as 2009. Possible armored vehicles located more than two kilometres away from the destroyed home are visible on 3 August.

Damage Assessment of Misratah: On 27 April 2011 UNOSAT conducted a rapid analysis of satellite imagery for Misratah, Libya to determine levels of damage, visible signs of combat and military activity, and road blocks and other barriers to transit in the area. Imagery from 10 April 2011 and 18 November 2010 was utilized for this analysis. Analysis indicated significant destruction at that time with multiple destroyed building and areas of debris and scorching. Large numbers of roadblocks and multiple military vehicles and light truck concentrations were also identified.

Damage Assessment of Tawerga: UNOSAT conducted a satellite-based assessment for Tawerga to determine damage related to NATO bombing and the capture of Tawerga by forces aligned with the National Transitional Council on or about 12 August 2011. This assessment covered two time periods to reflect damage occurring before and after capture of the town by anti-Gadaffi forces. Analysis indicated significant amounts of destruction taking place prior to capture of the town by anti-Gadaffi forces as well as numerous buildings destroyed after its capture.

Additional UNOSAT products for Libya providing damage assessments, airport status, refuge egress route analyses, navigational assistance, and more are available at <http://www.unitar.org/unosat/maps/LBY>. Please send feedback to UNITAR/UNOSAT at the contact information below.

OVERVIEW MAP



1. DESTROYED BUILDINGS AND POSSIBLE MILITARY ACTIVITY IN BANI WALID

Analysis of high-resolution satellite imagery for the Bani Walid area of Libya was conducted using multiple satellite images collected on 11 dates between 9 March and 5 October 2011. Analysis focused on four primary sites of interest communicated by the CoI, specifically the Tile Factory, the Medical Complex, the Three Factories, and the Jfara Family Home. A relatively significant amount of activity is visible throughout Bani Walid across the multiple dates for which UNOSAT had satellite imagery. May 22 was a particularly significant day with hundreds, possibly more than 1,000, of light trucks present around the town in groups and columns, and multiple possible light armored vehicles as well. The Medical Complex in particular has hundreds of vehicles group around it on that date. In addition, while the Three Factories often has some moderate vehicle activity around it, the Tile Factory has almost no activity visible across the image dates. Further details are provided below and on the following pages.

Tile Factory: Imagery review indicates very little activity recorded in the imagery at the coordinates provided. Images reviewed were acquired on March 9, and 23, May 22, September 4, 5, 13, 17, 18, 19, and 21, and October 5. Notable dates and details are as follows:

- 5 October: 3-4 light trucks visible in the area, one in the factory yard itself.
- 22 May: Several (5-10) light trucks are visible in the vicinity, as well as several heavy construction vehicles (likely front end loaders) in the factory yard.

Medical Complex: Imagery review indicates some notable activity recorded in the imagery at the coordinates provided. Images reviewed were acquired on February 18, March 9 and 23, May 22, September 4, 5, 8, 13, 17, 18, 19, and 21, and October 5. Notable dates and details are as follows:

- 22 May: At least 100-200 light trucks parked on the street directly to the west of the complex, stretching north to south. About 20 light SUV trucks are visible inside the complex on that date as well as 3-4 possible armored vehicles. Note there is a more consistent light truck presence in buildings 100-300 meters to north across multiple dates.

Three Factories: Imagery review indicates very little activity recorded at the coordinates provided. Images reviewed were acquired on March 9 and 23, May 22, September 4, 5, 13, 17, 18, 19, and 21, and October 5. Notable dates and details are as follows:

- One building was destroyed between 5 September and 13 September, and three additional buildings were destroyed between 21 September and 5 October.
- Several buildings within about 300 meters of the factories show occasional groupings of light SUV trucks numbering about 5 – 20 at a time.

Jfara Family Home: Imagery review indicates very little activity recorded at the coordinates provided. Images reviewed were acquired on February 18, March 9 and 23, May 22, September 4, 5, 8, 13, 17, 18, 19, and 21, and October 5. Notable dates and details are as follows:

- Imagery collected 22 May indicated large amounts of activity throughout Bani Walid consisting primarily of the presence of more than a thousand (estimated) light trucks and possible light armored vehicles in several areas of the city. One group of such vehicles was located 125 meters northeast of the Jfara compound on 22 May, and one light truck is visible within the Jfara compound on that day.
- On 4 September little activity is visible in the area around the Jfara compound, and about a dozen light trucks are visible 400-500 meters north.

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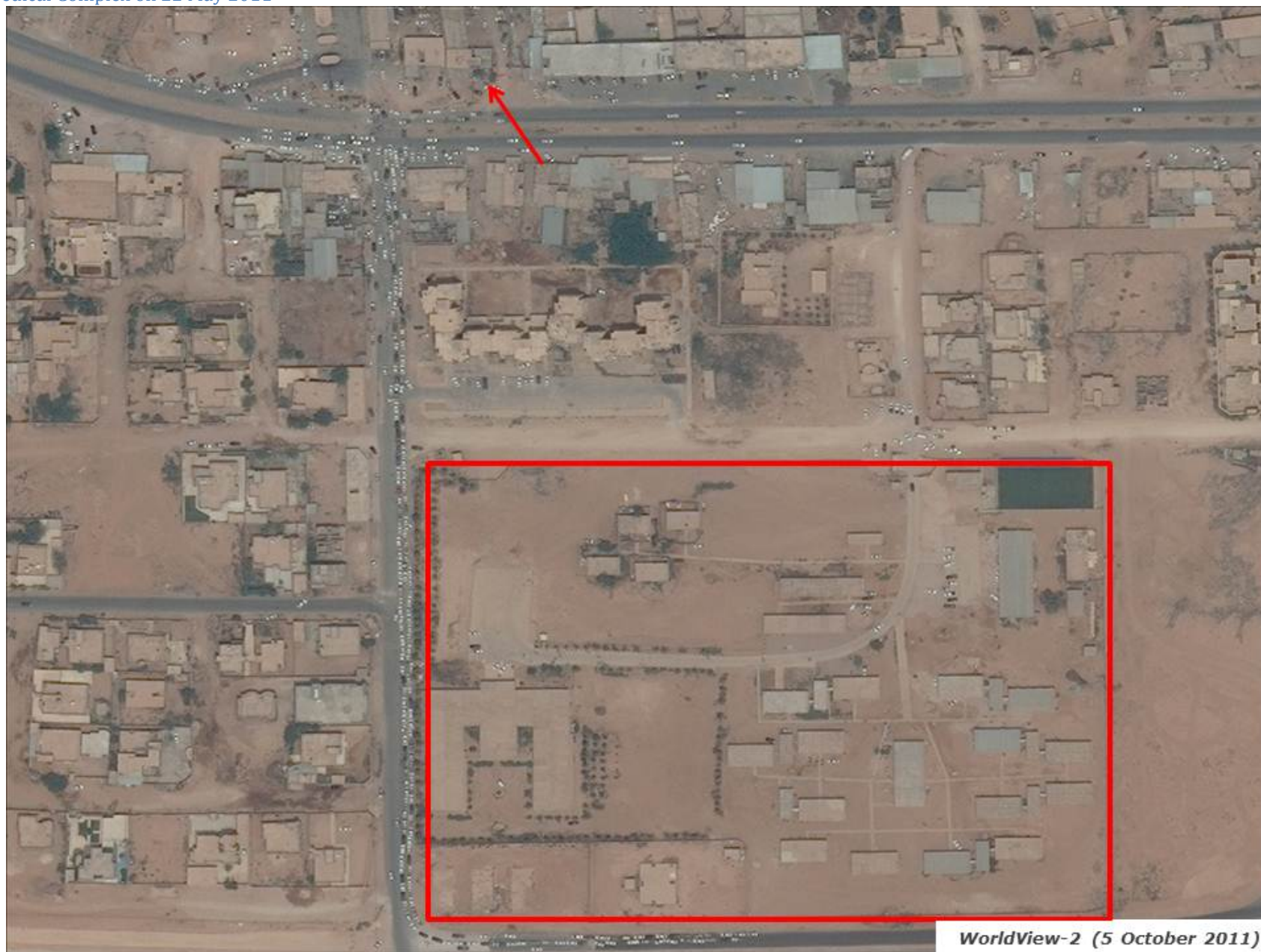
Figure 1. The Tile Factory on 5 October 2011



WorldView-2 (5 October 2011)

The two buildings (red arrows) of the Tile Factory on 5 October 2011. Very little vehicle activity was visible at this location across the multiple image dates. Though partially obscured by clouds, 3-4 light trucks are visible in the area with one in the factory yard (yellow arrow).

Figure 2. The Medical Complex on 22 May 2011



The Medical Complex (outlined in red) on 22 May 2011. Hundreds of light trucks and possibly dozens of armored vehicles are present in the area. Such vehicle concentrations were quite common across Bani Walid on this date. The buildings to the north (red arrow) saw consistent groups of vehicles present across most image dates.

Figure 3. The Three Factories on 22 May 2011



The Three Factories (red arrows) on 22 May 2011. Multiple vehicles are visible in the area, including several possible armored vehicles (blue arrows). Large numbers of vehicles were present across Bani Walid on that date.

Figure 4. The Three Factories on 5 October 2011



WorldView-2 (5 October 2011)

The Three Factories area on 5 October 2011. One building (red arrow) was destroyed between 5 and 13 September. An additional three buildings (blue arrows) were destroyed between 21 September and 5 October. One proximate building remained largely intact (yellow arrow).

Figure 5. The Jfara Home on 22 May 2011



WorldView-2 (22 May 2011)

The buildings of the Jfara compound in Bani Walid (red arrows).

Figure 6. The Jfara Home on 4 September 2011



The remains of the buildings of the Jfara compound (red arrows).

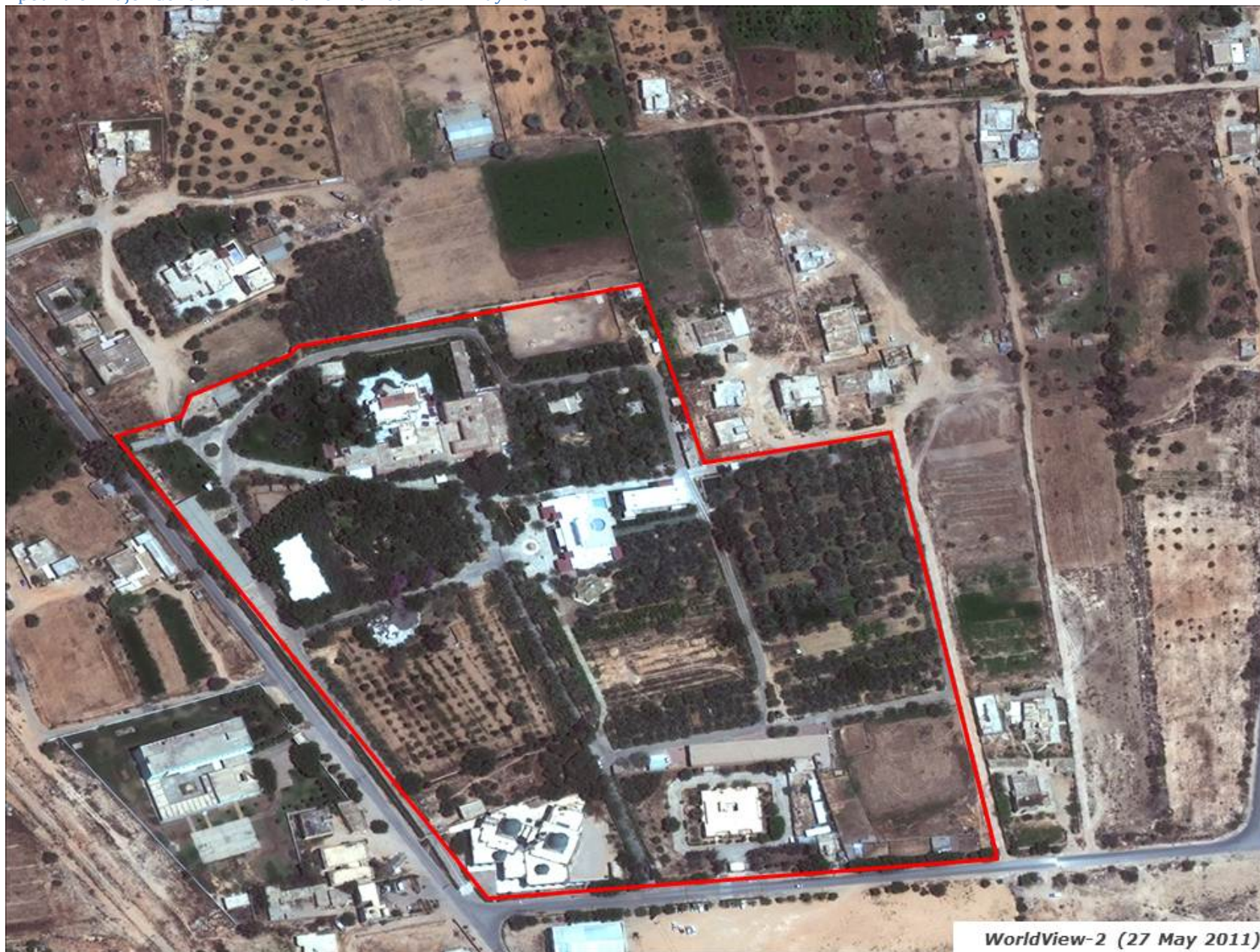
2. DESTRUCTION OF THE COMPOUND OF MAJOR GENERAL EL-KHWELDI EL-HAMEDI

The compound of Major General El-Khweldi el-Hamedy was analysed using two satellite images acquired on 27 May and 15 July 2011. A review of the surrounding 25 square kilometres on 27 May 2011 located 4 possible military vehicles about 2.5 kilometres away and no significant activity in the direct vicinity of el-Hamedy's compound beyond a few scattered light trucks and other vehicles. By 15 July 2011 most buildings in the compound have clearly been destroyed or severely damaged, and a vehicle with dimensions corresponding to a BMP-type infantry fighting vehicle is also visible within the walls of the compound. Additional buildings across the street with a likely transceiver antenna tower have also been destroyed or severely damaged in the same time period.

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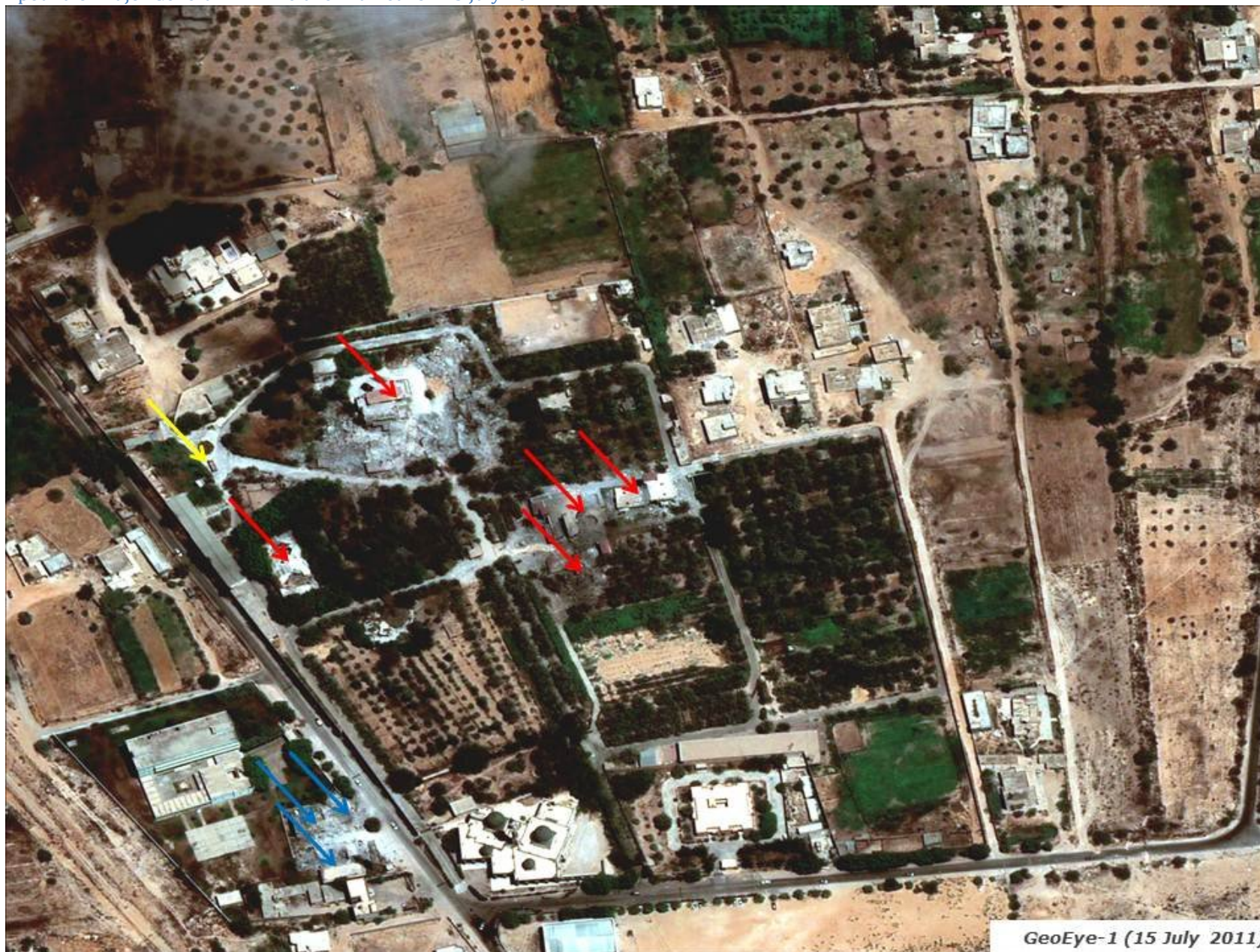
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Figure 7. The compound of Major General El-Khweldi el-Hamedy on 27 May 2011



The compound of Major General El-Khweldi el-Hamedy on 27 May 2011 (red outline). A review of the surrounding 25 square kilometres on that date located 4 possible military vehicles about 2.5 kilometres away.

Figure 8. The compound of Major General El-Khweldi el-Hamedi on 15 July 2011



The compound of Major General El-Khweldi el-Hamedi on 15 July 2011. Most buildings have clearly been destroyed or severely damaged (red arrows), and a vehicle with dimensions corresponding to a BMP infantry fighting vehicle is also visible (yellow arrow). Additional buildings across the street with a likely transceiver antenna tower have also been destroyed or severely damaged (blue arrows).

3. DAMAGE ASSESSMENT AND IMAGERY SAMPLES FOR SIRTE

Analysis of high-resolution satellite imagery for the city of Sirte and its immediate vicinity was conducted using multiple satellite images acquired on multiple dates between 16 September and 22 October 2011. Primary imagery analysed were collected on September 16, 17, 19, 25, 26, and 27 and October 5, 21, and 22. Additional images collected prior to 16 September were also occasionally reviewed for a few specific locations as needed. Within the city of Sirte a few areas of damage were visible by 16 September, and much greater amounts of damage and destruction were visible by 22 October 2011. Damage observed includes debris, collapsed buildings, numerous flooded areas, and the aftermath of airstrikes on civilian homes and on vehicles near a traffic circle. On-the-ground photographs indicate that a large portion of the damage inflicted on buildings in Sirte occurred to facades and interiors, and thus would not be visible to satellite imagery. Therefore, the damage assessment conducted by UNOSAT should be viewed as a proxy indicator for damage to buildings. Vehicle concentrations, both destroyed and intact, resulting from the capture of Gadaffi as well as possible and confirmed groups of body bags are visible in imagery from 21 and 22 October. Further details are provided below.

Sirte Damage Assessment: An assessment using satellite imagery spanning the period of 16 September and 22 October 2011 was conducted to determine damage to buildings and other areas occurring prior to and during that period. Imagery indicates little damage was visible in Sirte on 16 September 2011, and significant amounts of destroyed or damaged buildings, debris, scorching, flooding, and other signs of combat are visible by 22 October 2011.

Water Treatment Facility: an assessment of the Sirte water treatment facility, near where Gadaffi was captured on 20 October 2011, was done using an image from 21 October 2011. A smoke plume is clearly visible in a structure near the edge of the facility, as are several possibly destroyed light trucks.

Gadaffi Capture Area: the area of Gadaffi's capture is visible in a satellite image acquired 22 October 2011. Numerous destroyed and intact light trucks are visible, as are multiple body bags confirmed by on-the-ground photographs.

The Mahari Hotel: the Mahari Hotel was assessed using satellite images from both 21 and 22 October 2011. Using photographs taken on the ground likely bodies covered by sheets, blankets, and body bags were counted, indicating 13 likely bodies on 21 October and 22 likely bodies on 22 October 2011. In addition, multiple light trucks are visible at the location.

Military Vehicle Strike: the area of an airstrike on military vehicles was analysed using imagery from 16 September 2011. Remains of the vehicles are clearly visible as are proximate road blocks.

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MAP 1: SIRTE DAMAGE ASSESSMENT - 16 SEPTEMBER 2011

Analysis with WorldView-2 Data Acquired 4 April and 16 September 2011

MAP DESCRIPTION: This map illustrates satellite-detected areas of damaged and destroyed buildings as well as visible areas of debris, scorching, craters, and roadblocks in Sirte and the surrounding area as seen on 16 September 2011. Throughout the analysis area 54 buildings were identified as damaged or destroyed in the period between 4 April and 16 September 2011. Additionally, 5 locations

showed signs of debris and scorching, and an additional 34 locations featured road blocks constructed in the same period. This is a preliminary analysis and has not yet been validated in the field. Please send ground feedback to UNITAR / UNOSAT.

Civil Conflict

Production Date:
21/02/2012

Version 1.0

Activation Number:
CE20110220LBV



LEGEND

- Damaged and Destroyed Buildings
- Debris, Scorching, and Craters
- ◆ Road Blocks
- Primary Roads
- Local Roads
- UNOSAT Analysis Extent

Map Scale for A3: 1:40,452,586
0 0.15 0.3 0.6 0.9 1.2 1.5 Km

Satellite Data (1): WorldView-2
Imagery Dates: 16 September 2011

Resolution: 50 cm

Copyright: DigitalGlobe

Source: FirstLook

Satellite Data (2): WorldView-2

Imagery Date: 4 April 2011

Copyright: DigitalGlobe

Source: FirstLook

Road Data: Google Map Maker / OSM / ESRI

Other Data: USGS, UNCS, NASA, NGA

Analysis: UNITAR / UNOSAT

Production: UNITAR / UNOSAT

Coordinate System: WGS 1984 UTM Zone 33N

Projection: Transverse Mercator

Datum: WGS 1984

Units: Meter

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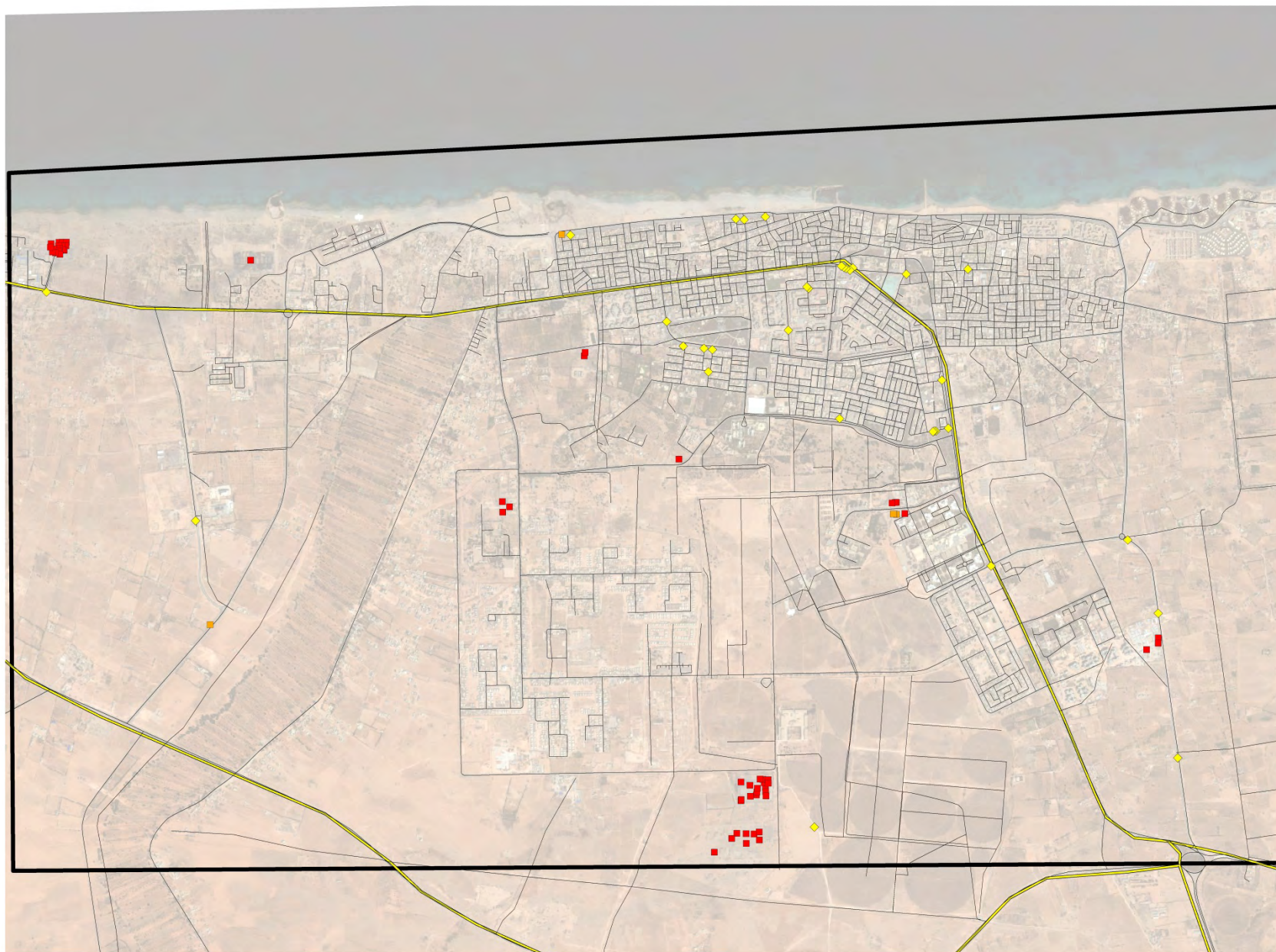
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MAP 2: SIRTE DAMAGE ASSESSMENT - 22 OCTOBER 2011

Analysis with WorldView-1 and WorldView-2 Data Acquired 21 and 22 October & WorldView-2 Data Acquired 16 September 2011

MAP DESCRIPTION: This map illustrates satellite-detected areas of damaged and destroyed buildings as well as visible areas of debris, scorching, craters, and roadblocks in Sirte and the surrounding area as seen on 21 and 22 October 2011. Throughout the analysis area 212 buildings were identified as damaged or destroyed in the period between 16 September and 22 October 2011. Additionally, 67 locations showed signs of debris, scorching, and craters, 41

locations featured road blocks constructed in the same period, and 9 areas within the city of Sirte indicated flooded streets. Evaluation of on-the-ground photographs taken indicate that the vast majority of damage in Sirte would not be visible to satellites and thus this assessment does not fully document all destruction. This is a preliminary analysis and has not yet been validated in the field. Please send ground feedback to UNITAR / UNOSAT.

Civil Conflict

Production Date:
10/02/2012

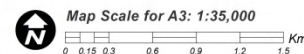
Version 1.0

Activation Number:
CE20110220LBY



LEGEND

- Damaged and Destroyed Buildings
- Debris, Scorching, and Craters
- Flooding
- ◆ Road Blocks
- Primary Roads
- Local Roads
- UNOSAT Analysis Extent



Satellite Data (1): WorldView-2
Imagery Dates: 22 October 2011

Resolution: 50 cm
Copyright: DigitalGlobe
Source: FirstLook

Satellite Data (2): WorldView-1
Imagery Date: 21 October 2011
Copyright: DigitalGlobe
Source: FirstLook

Satellite Data (3): WorldView-2
Imagery Date: 16 September 2011
Copyright: DigitalGlobe
Source: FirstLook

Road Data: Google Map Maker / OSM / ESRI
Other Data: USGS, UNCS, NASA, NSA
Analysis: UNITAR / UNOSAT
Production: UNITAR / UNOSAT

Coordinate System: WGS 1984 UTM Zone 33N
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

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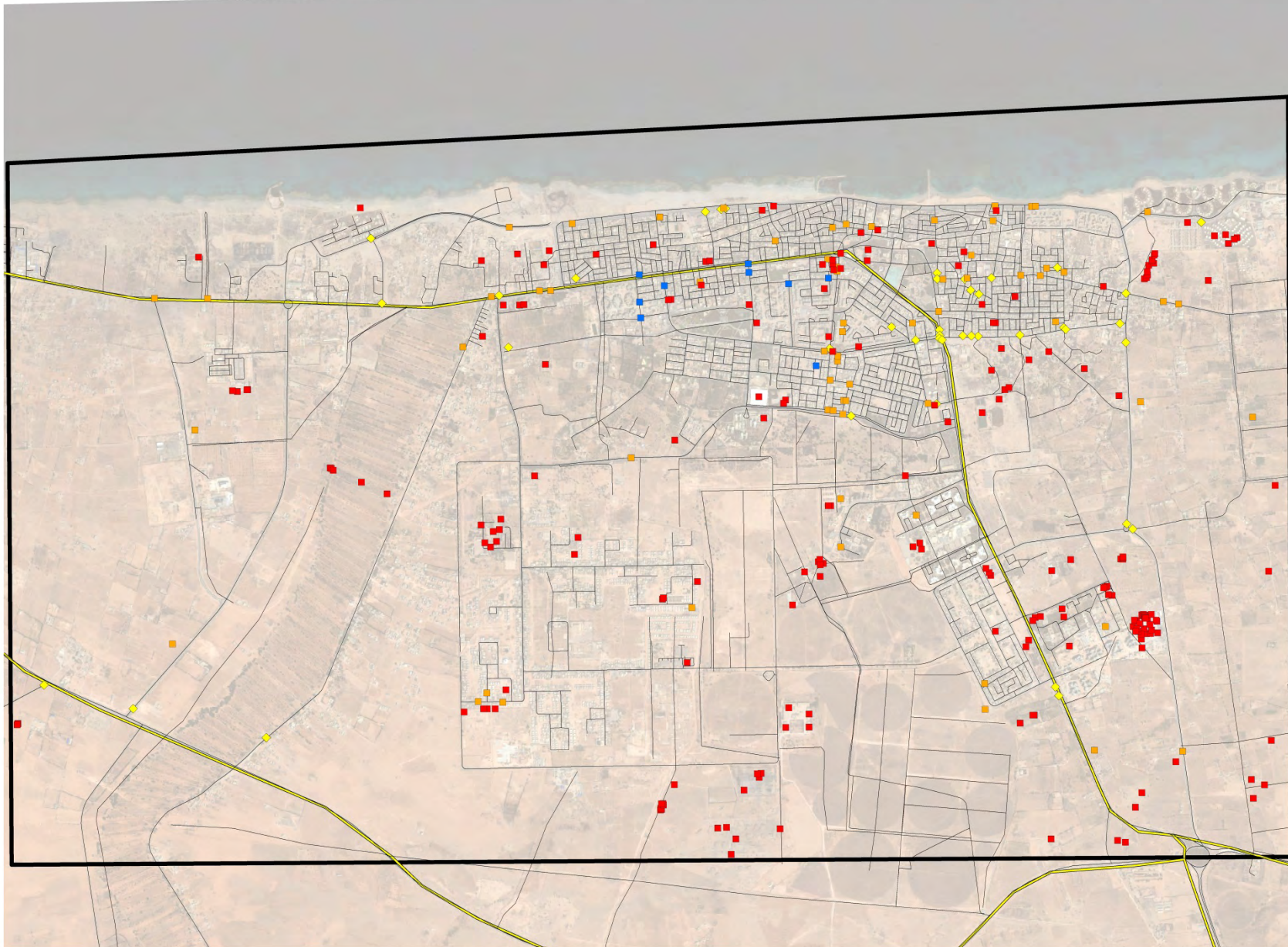
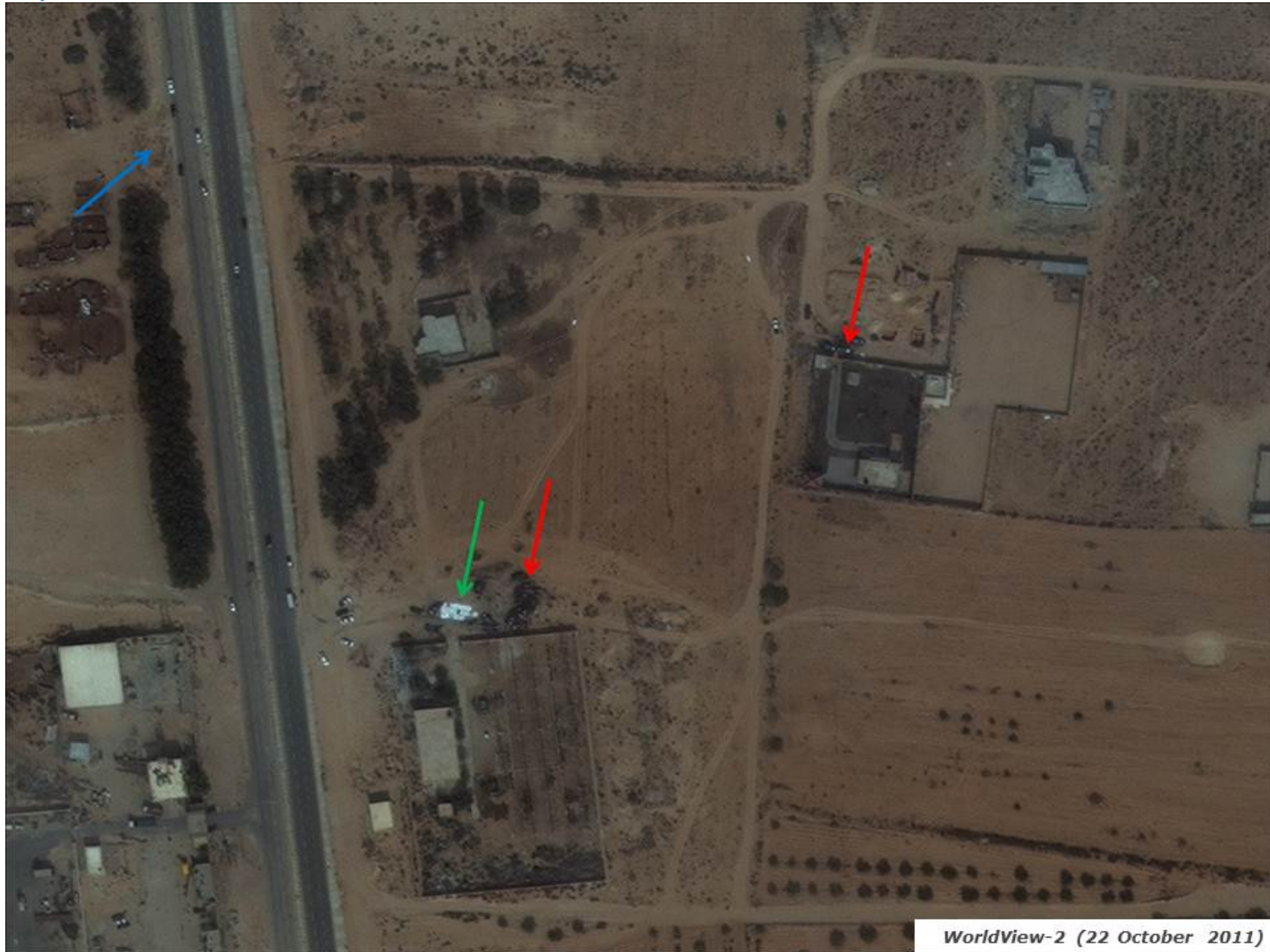


Figure 10. Sirte water treatment facility



A smoke plume (red arrow) from a small fire burning at the water treatment plant near where Gadaffi was captured. Multiple light trucks commonly used in the fighting also visible nearby.

Figure 11. Gadaffi capture area



The area of Moammar Gadhafi's capture. Destroyed light trucks (red arrows) are visible, as are body bags (green arrow). The culvert area where Gadhafi was apprehended is indicated with a blue arrow.

Figure 12. Mahari Hotel



The Mahari Hotel area near Sirte. Twenty-two covered bodies identified by the on the ground photos possibly visible (red arrows), and numerous light trucks are present (yellow arrows). Location showed similar activity the previous day (21 October), though with less vehicles and 13 possible covered bodies.

Figure 13. Military vehicle strike area



The area of the 'Military Vehicle Strike'. Roadblocks (red arrows) are visible, as well as the aftermath of the airstrike (yellow arrow), which includes 2 – 3 destroyed vehicles. The roadblock on the primary road was constructed between 3 and 6 September.

4. DESTROYED BUILDING IN TRIPOLI

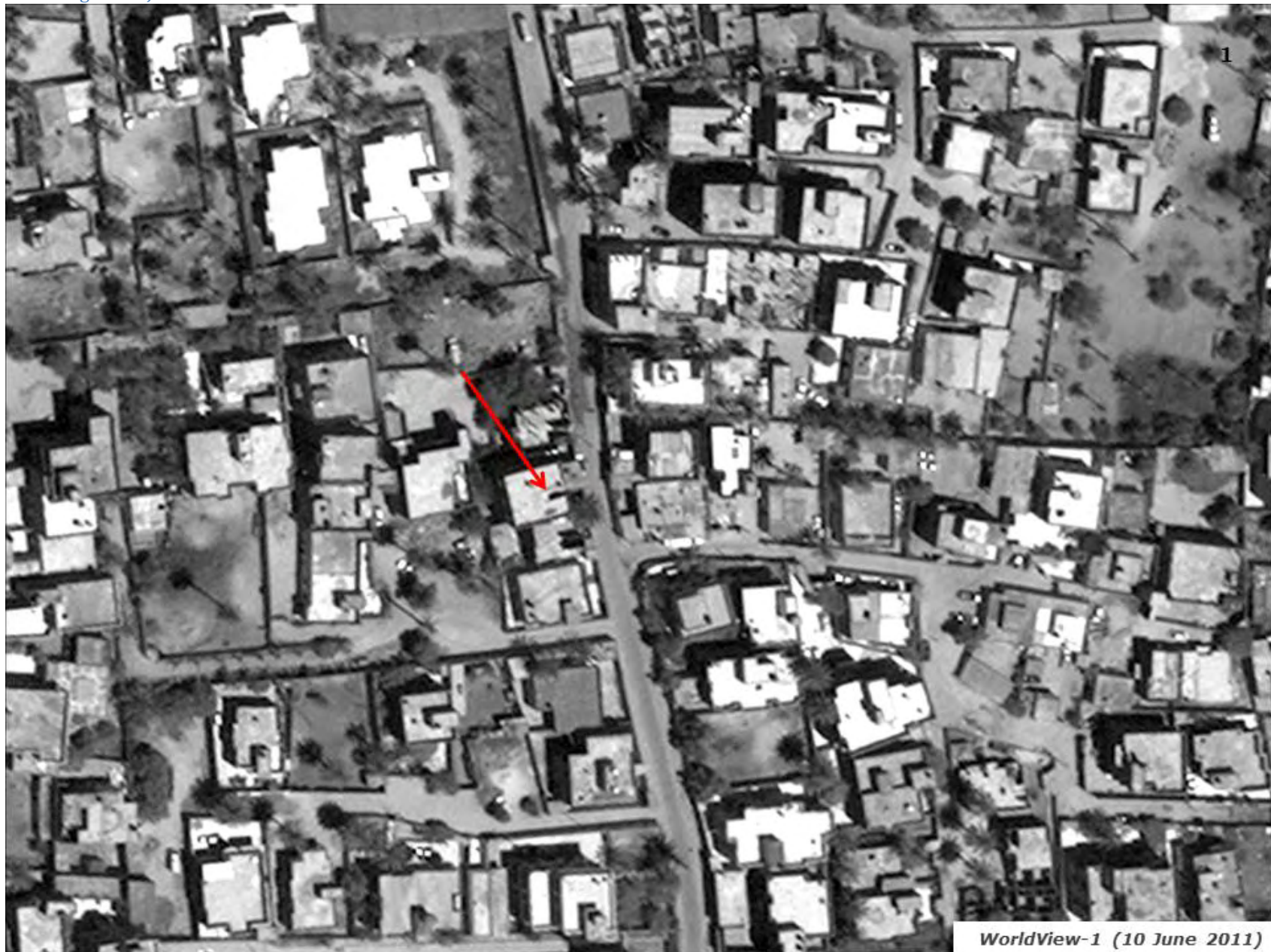
Analysis of high-resolution satellite imagery for a single building in Tripoli located about one kilometer south of the Umm Aitiwah Airfield was done using multiple satellite images from the WorldView-1, WorldView-2, and QuickBird satellites. Images used in this analysis were acquired on 7 June, 10 June, 21 August, 22 August, and 23 August.

Imagery clearly indicates that the home at the location in question was destroyed sometime between 10 June and 21 August. While damage is confined to the one building in question and relatively subtle the various post-destruction images indicate the building is clearly collapsed and damage to proximate vegetation is also apparent. Images collected on 22 August and 23 August 2011.

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Figure 18. Tripoli building on 10 June 2011



The location in question (see red arrow) on 10 June 2011. Structure is intact, the rooftop is clearly delineated, and a tree on the roadside next to the structure is visible.

Figure 19. Tripoli building on 21 August 2011



WorldView-1 (21 August 2011)

The location in question (see red arrow) on 21 August 2011. Though of poor quality the image clearly shows changes in the roof of the structure, indicating building collapse, and the proximate tree is gone.

Figure 20. Tripoli building on 22 August 2011



The location in question (see red arrow) on 22 August 2011. The appearance of the roof is markedly different compared with the image from 10 June, and a clearer view of the collapsed portion of the building is apparent.

Figure 21. Tripoli building on 23 August 2011



An additional image of the structure (see red arrow) was collected on 23 August 2011. The angle of the image acquisition provides a view of the collapsed front of the building with concrete debris likely accounting for the lighter appearance of the adjacent street.

5. DESTRUCTION OF THE MOSQUE AT MARTYRS' SQUARE, ZAWIYAH

Analysis of high-resolution satellite imagery collected on March 8, 14, and 20 indicates that the mosque at Martyr's Square in Zawiyah was razed sometime between 8 March and 14 March 2011. A satellite image collected by the GeoEye-1 satellite on 8 March shows the mosque clearly intact on that date, and with tanks and evidence of combat also visible in its immediate vicinity. The next image of Zawiyah was collected on 14 March by the WorldView-2 satellite, and indicates the mosque had been razed and the property largely swept clean by that date. Additionally, though the quality of the 14 March image is poor, almost 50 light trucks commonly used by combatants in the Libyan conflict are visible in the immediate vicinity of Martyr's Square and the mosque, and two dump trucks as well as a possible front-end loader and cement truck are visible directly adjacent to where the mosque had been. A higher-quality image from 20 March clearly shows the absence of the mosque as well as proximate heavy equipment.

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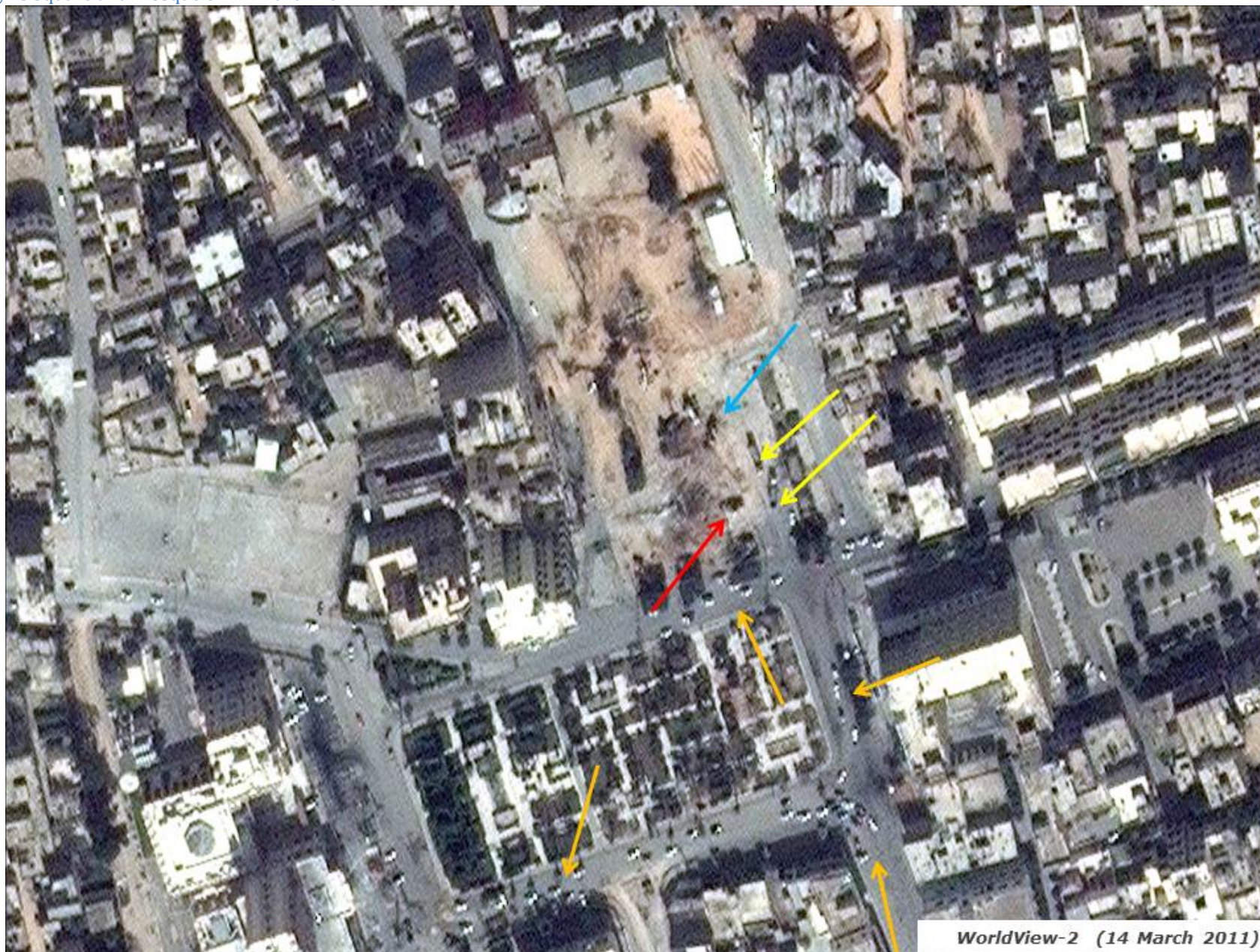
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Figure 22. Martyr's Square and mosque on 8 March 2011



The mosque in Martyr's Square in Zawiyah (red arrow) on 8 March 2011 as pro-Gadaffi forces were attacking the city. Two tanks are visible (yellow arrows) with guns pointed across the square.

Figure 23. Martyr's Square and mosque on 14 March 2011



Martyr's Square after capture by pro-Gadaffi forces on 14 March 2011. The mosque has been removed (red arrow) and a front end loader is visible (blue arrow), as well as dump trucks (yellow arrows). Several groups of light trucks are also present in and around the square (orange arrows).

Figure 24. Martyr's Square and mosque on 20 March 2011



A higher quality image showing Martyr's Square on 20 March 2011. The area of the razed mosque is indicated by a red arrow, and several heavy construction vehicles are visible (blue arrows). Numerous light trucks are also visible in and around the square.

6. DESTROYED HOUSING IN THE AREA OF AL HUWAYJAT, SOUTH OF ZILTAN

Analysis of high-resolution satellite imagery for the area of Al Huwayjat, south of Ziltan, Libya was done using images collected by the GeoEye-1 satellite on 6 August and 9 August 2011. Imagery analysis indicates significant damage took place during this three day period as multiple homes were destroyed as well as a block of seven apartment buildings. There is evidence of explosions and burning visible in the imagery near both the destroyed homes and the apartment buildings.

Several concentrations of light trucks are also visible in the area, with one large group parked along the side of the road on both 6 and 9 August, and less than a kilometer north of the destroyed homes. Two possible multiple rocket launcher vehicles were also located approximately 1700 meters from the destroyed homes and are likewise visible on both 6 and 9 August 2011. Finally, there are also several locations in the area that were clearly bombed and destroyed prior to 6 August.

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Figure 26. Four homes in Ziltan area on 6 August 2011



Homes and outbuildings (red arrows) targeted by airstrikes as seen on 6 August 2011.

Figure 25. Four homes in Ziltan area on 9 August 2011



Multiple homes and structures in this area were destroyed or severely damaged (see red arrows) as seen in this image from 9 August 2011. Circular patterns of scorching, especially in the top left destroyed structure, are consistent with significant explosions.

Figure 27. Possible multiple rocket launcher vehicles on 6 August 2011



Two possible multiple rocket launcher vehicles (red arrows) with firing tubes elevated. These vehicles are located 1700 meters southwest of the targeted buildings and oriented towards the southeast. Vehicles are visible in almost the exact same position on both 6 and 9 August 2011.

Figure 28. Light truck convoy on 9 August 2011



GeoEye-1 (9 August 2011)

This line of light trucks stretched for more than 500 meters and is located less than one kilometer north of the destroyed homes shown in previous pages. The trucks are visible in imagery from both 6 and 9 August 2011. Image has been rotated 90 degrees for presentation purposes.

Figure 29. Destroyed apartment block



A block of apartment buildings were destroyed (see red arrow) between 6 and 9 August 2011. Four buildings were completely destroyed and collapsed, three others were severely damaged, and one likely suffered significant fire damage.

7. DESTROYED BUILDING NEAR ZILTAN

Analysis of high-resolution satellite imagery for a single building in the Ziltan area was done using satellite images from the GeoEye-1 satellite acquired on 3 and 6 August 2011 as well as an image found on Google Earth acquired on 3 August 2009. Imagery clearly indicates that the building at the location in question was destroyed sometime between 3 August and 6 August 2011. Damage is clearly visible and the home is largely collapsed with debris found in the street. Rapid review of the surrounding area indicates several areas with possible armored vehicles as well as roadblocks. Two clusters of light trucks are also visible about 500 meters to the southwest of the home on 3 and 6 August 2011. Historical imagery from 2009 also shows significant numbers of vehicles at that location, indicating it is likely a market area or another similar community gathering point.

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Figure 30. Ziltan home on 3 August 2011



GeoEye-1 (3 August 2011)

The location in question (see red arrow) on 3 August June 2011. Structure is intact and the rooftop clearly delineated.

Figure 31. Ziltan home on 6 August 2011



The location in question (red arrow) on 6 August 2011. The image clearly shows heavy damage and partial collapse of the structure. Multiple light trucks are also now visible on the proximate road.

Figure 32: Vehicle concentrations near the Ziltan home on 3 August 2011



Two areas of vehicle concentrations (red arrows) located 400 meters southwest of the targeted house on 3 August 2011. Imagery from 2009 also shows large numbers of vehicles in this area, suggesting it may be a market area or similar community gathering point.

Figure 33: Possible armored vehicles near the Ziltan home on 3 August 2011



Several possible armored vehicles (red arrows) located about 2.4 kilometres west of the targeted building on 3 August 2011. Dimensions are consistent with BMP type infantry fighting vehicles and they are no longer present by 6 August. Multiple light trucks are also visible.

8. MISRATAH DAMAGE ASSESSMENT

On 27 April 2011 UNOSAT conducted a rapid analysis of satellite imagery for Misratah, Libya to determine levels of damage, visible signs of combat and military activity, and road blocks and other barriers to transit in the area. Imagery from 10 April 2011 and 18 November 2010 was utilized for this analysis. Analysis results indicated 152 debris areas, 60 areas of visible scorching, 31 buildings destroyed or severely damaged, five visible impact craters, 990 roadblocks and security checkpoints, five military vehicles, and 36 concentrations of light trucks.

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MAP 1: DAMAGE ASSESSMENT FOR MISRATAH: 10 APRIL 2011

Analysis with GeoEye-1 Data Acquired 10 April 2011 and 18 November 2010

MAP DESCRIPTION: This map illustrates satellite-detected areas of damaged and destroyed buildings as well as visible areas of debris, scorching, heavy vehicle tracks, craters, roadblocks, and checkpoints in Misratah as seen on 10 April 2011. Throughout the analysis area 31 buildings were identified as destroyed or severely damaged. Additionally, 152 locations showed evidence of debris, 60 locations indicated visible scorching, five impact craters were

visible, 990 roadblocks and security checkpoints were located, five military vehicles were identified, and 36 concentrations of light trucks were counted. Note that road data in this product is incomplete due to gaps in the source data (see source information below). This is a preliminary analysis and has not yet been validated in the field. Please send ground feedback to UNITAR / UNOSAT.

Civil Conflict

Production Date:
27/02/2012

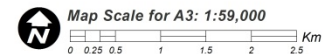
Version 1.0

Activation Number:
CE20110220LBY



LEGEND

- Damaged or Destroyed
- Debris, Scorching, Tracks, and Craters
- ◆ Road Blocks and Checkpoints
- Military Vehicle
- Vehicle Concentration
- UNOSAT Analysis Extent
- Primary Roads
- Local Roads

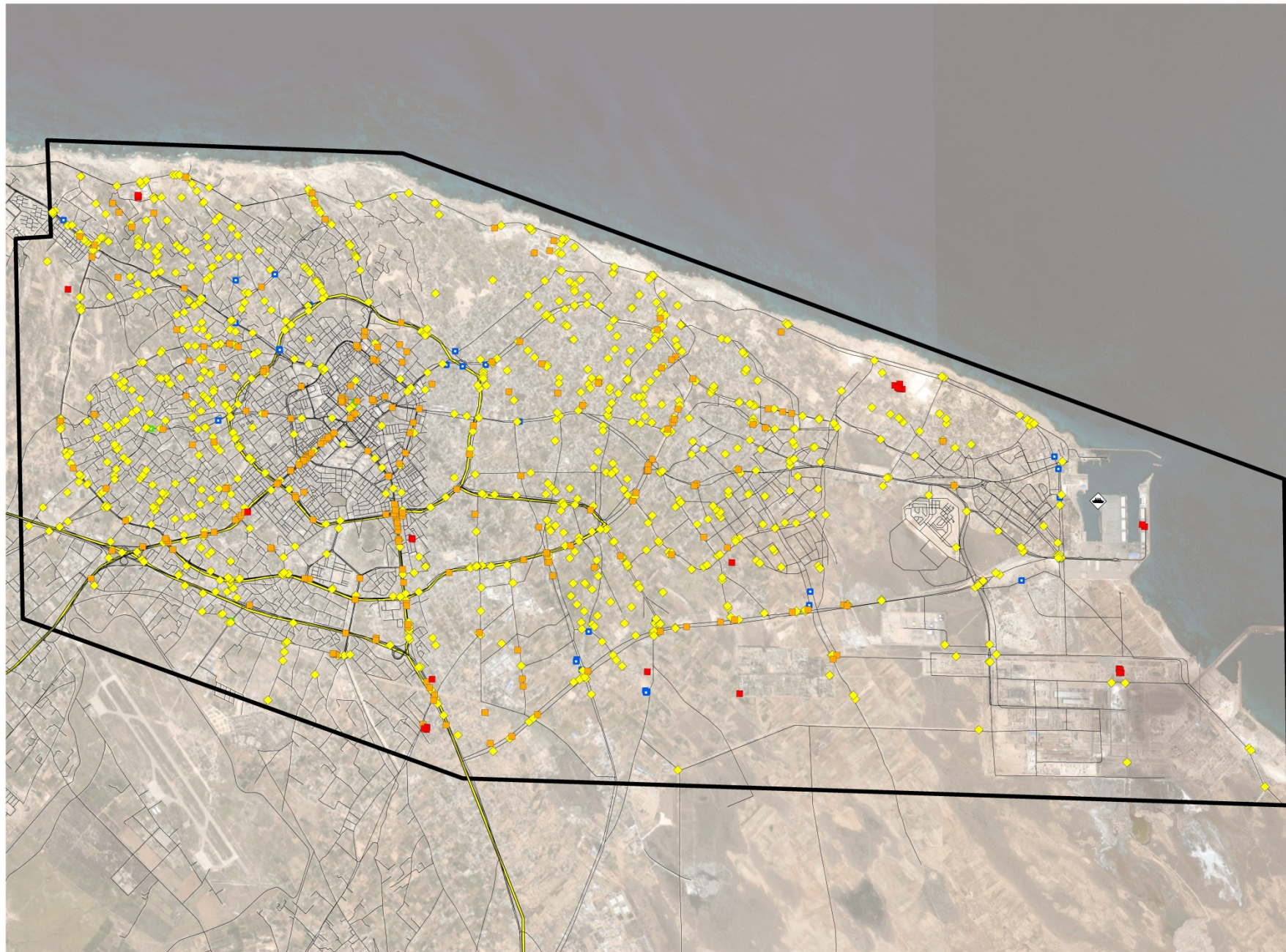


Satellite Data (1): GeoEye-1
Imagery Dates: 10 April 2011
Resolution: 50 cm
Copyright: GeoEye
Source: eGeos
Satellite Data (2): GeoEye-1
Imagery Date: 18 November 2010
Copyright: GeoEye
Source: eGeos
Road Data: Google Map Maker / OSM / ESRI
Other Data: USGS, UNCS, NASA, NGA
Analysis: UNITAR / UNOSAT
Production: UNITAR / UNOSAT

Coordinate System: World Robinson
Projection: Robinson
Datum: WGS 1984
Units: Meter

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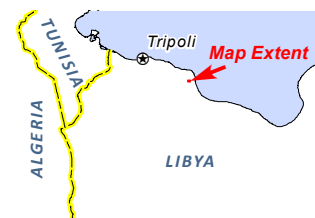


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Production Date: 24/02/2012
Version 1.0
Activation Number: CE20110220LBY

9. ANALYSIS OF BUILDING DESTRUCTION IN TAWERGA



20 August - 24 November 2011



Copyright (DigitalGlobe 2011)

Remnants of buildings and evidence of burning in Tawerga.

Center Coordinates: 14°3'56.77"E 30°39'2.06"N

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Satellite Data (1): WorldView-1
Imagery Dates: 24 November 2011
Resolution: 50 cm
Copyright: DigitalGlobe
Source: European Space Imaging
Satellite Data (2): WorldView-2
Imagery Date: 20 August 2011
Copyright: DigitalGlobe

Source: DigitalGlobe
Satellite Data (3): GeoEye-1
Imagery Date: 12 June 2009
Copyright: GeoEye
Source: Google Earth
Road Data : Google Map Maker /
OSM / ESRI
Other Data: USGS, UNCS, NASA,

NGA
Analysis : UNITAR / UNOSAT
Production: UNITAR / UNOSAT
Coordinate System: WGS 1984 Web
Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
Units: Meter

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11 December 2011– Version 1.0

UNOSAT Activation: CE20110220LBY

Conflict Analysis: Tawerga, Sawfajjin District, Libya

PREFACE: This report provides an analysis of damage and destruction occurring in the town of Tawerga, Libya. UNOSAT conducted a satellite-based assessment for Tawerga to determine damage related to NATO bombing and the capture of Tawerga by forces aligned with the National Transitional Council on or about 12 August 2011. Specifically, an assessment of the town as of 20 August 2011 was done using an image from the WorldView-2 satellite. A second assessment as of 24 November 2011 was done using an image from the WorldView-1 satellite. An image from Google Earth, acquired on 12 June 2009 by the GeoEye-1 satellite, was used as a baseline for comparison.

Additional UNOSAT products for Libya are available at <http://www.unitar.org/unosat/maps/LBY>. This report is part of an on-going satellite monitoring program of UNITAR / UNOSAT of the recent conflict in Libya in support of international humanitarian assistance and created to respond to the needs of UN agencies and their partners. This assessment has not yet been validated in the field. Please send feedback to UNITAR/UNOSAT at the contact information below.

1. Damage and Destruction Occurring Prior to 20 August 2011

Between 12 June 2009 and 20 August 2011 a total of 49 structures were identified as destroyed or damaged in Tawerga. Multiple facilities such as warehouses, industrial areas, and individual buildings are clearly destroyed and often showing indications of fire. An apparent wastewater treatment facility shows selective destruction of its cooling tower facilities by 20 August (see Figure 1). In addition, several armored vehicles and concentrations of light trucks are also apparent in the 20 August satellite image (see Figure 2).

2. Damage and Destruction Occurring Between 20 August and 24 November 2011

Between 20 August and 24 November 2011 an additional 27 buildings were destroyed or damaged (see Figure 3). These buildings largely consist of likely residential and commercial structures. No armored vehicles and few light trucks are visible in the 24 November imagery. A relatively large smoke plume from a fire is visible in central Tawerga (see Figure 4), though it is unclear whether it originates from a building or not. Several groups of construction related vehicles visible in the 20 August image are no longer visible by 24 November 2011.

3. Possible Causes of Building Destruction

Causes of the building destruction are not readily apparent but are certainly conflict related. While several of the destroyed building and facilities visible in the 20 August image show clear signs of burning there is only one apparent crater visible. There is little, if any, scattered debris around the destroyed buildings and facilities that would be indicative of larger air dropped munitions. Proximate trees and fencing likewise remain intact (see Figure 5). Review of NATO Operational Media Updates¹ provided information on airstrikes in the area of Tawerga, indicating that NATO aircraft made attacks on four separate occasions. Specifically:

- on 4 August NATO hit two artillery pieces;
- on 5 August NATO hit one multiple rocket launcher system staging area and one military checkpoint;
- on 10 August NATO hit 3 command and control nodes and two military storage facilities, and;
- on 13 August NATO hit two military vehicles and one anti-aircraft gun.

It is possible that relatively small air dropped munitions were used to destroy the sites in Tawerga, explaining the lack of scattered debris and nearby damage. However, in several of the cases it is likely that destruction occurred with great precision and no damage to the surrounding area, likely indicating the use of directly applied explosives or direct fire ground munitions rather than indirect fire or air dropped munitions.

¹ See: http://www.nato.int/cps/en/natolive/news_71994.htm



Figure 1 - Wastewater treatment facility with cooling towers destroyed (red arrow) by 20 August 2011



Figure 2 – Tank (red arrow) and other vehicles in Tawerga on 20 August 2011



Figure 3 – Multiple structures destroyed by 24 November 2011 (indicated by red arrows). Structures were intact on 20 August.



Figure 4 – A smoke plume in central Tawerga. It is unclear whether the proximate building or something else is the source.



Figure 5 – Destroyed facility on 20 August 2011 with crater visible (red arrow). Debris is minimal and trees and fencing remain intact.

APPENDIX I: SUMMARY OF SATELLITE IMAGES REVIEWED BY UNOSAT

DESTROYED BUILDINGS AND POSSIBLE MILITARY ACTIVITY IN BANI WALID

Tile factory

March 9, and 23, May 22, September 4, 5, 13, 17, 18, 19, and 21, and October 5, 2011

Medical school complex

February 18, March 9, and 23, May 22, September 4, 5, 8, 13, 17, 18, 19, and 21, and October 5, 2011.

Three factories

March 9 and 23, May 22, September 4, 5, 13, 17, 18, 19, and 21, and October 5, 2011

Jfarra home

February 18, March 9, and 23, May 22, September 4, 5, 8, 13, 17, 18, 19, and 21, and October 5, 2011

DESTRUCTION OF THE COMPOUND OF MAJOR GENERAL EL-KHWELDI EL-HAMED

May 27 and July 15, 2011

DAMAGE ASSESSMENT AND IMAGERY SAMPLES FOR SIRTE

September 16, 17, 19, 25, 26, and 27 and October 5, 21, and 22, 2011. Additional images collected prior to 16 September were also occasionally reviewed for a few specific locations as needed.

DESTROYED BUILDING IN TRIPOLI

June 7, 10, and 21 and August 22, and 23, 2011

DESTRUCTION OF THE MOSQUE AT MARTYRS' SQUARE, ZAWIYAH

March 8, 14, and 20, 2011

DESTROYED HOUSING IN THE AREA OF AL HUWAYJAT, SOUTH OF ZILTAN

August 6 and 9, 2011

DESTROYED BUILDING NEAR ZILTAN

August 3 and 6, 2011

MISRATAH DAMAGE ASSESSMENT

November 18, 2010 and April 10, 2011

ANALYSIS OF BUILDING DESTRUCTION IN TAWERGAH

June 12, 2009, and August 20 and November 24, 2011

This is a preliminary assessment and has not yet been validated in the field. Please send feedback to UNITAR/UNOSAT at the contact information below.

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