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United Nations Institute for Training and Research

# Satellite image analysis in support to the United Nations Fact Finding Mission on the Gaza Conflict

A report to the UN Office of the High Commissioner for Human Rights (UN OHCHR)

31 July 2009

Prepared by UNITAR Operational Satellite Applications Programme (UNOSAT)



**Knowledge** to lead



## Table of contents

Executive summary .....	ii
Background.....	1
Methodology .....	3
Results .....	5
<i>Rafah damage assessment</i> .....	6
<i>Gaza neighbourhoods damage assessment</i> .....	14
<i>Greenhouses</i> .....	23
<i>Industrial facilities</i> .....	28
Conclusions.....	34



## Executive summary

This report was prepared by the United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT) on request from the United Nations Office for the High Commissioner of Human Rights (UN OHCHR) in support to the United Nations Fact Finding Mission on the Gaza. This independent fact finding mission was established by the President of the Human Rights Council, Ambassador Martin Ihoeghian Uhomobhi, pursuant to Resolution S-9/1 of the Human Rights Council (HRC) , to investigate all violations of International Human Rights Law and International Humanitarian Law that might have been committed at any time in the context of the military operations that were conducted in Gaza during the period from 27 December 2008 and 18 January 2009, whether before, during or after. Analysis of satellite imagery was requested in order to obtain factual information on the time at which certain buildings were damaged and quantitative assessments of the damage caused to certain types of facilities.

This report covers analyses over four specific areas and themes as requested by OHCHR:

1. Rafah damage assessment
2. Gaza neighbourhoods damage assessments
3. Greenhouses
4. Industrial facilities

This assessment has been carried out using a time series of very high resolution commercial satellite images (WorldView and QuickBird) acquired on 6,10,16,19 & 21 January 2009, as well as pre-conflict imagery from 27 September 2005 (Ikonos) and 14 June 2007 (QuickBird). The commercial copyrights to the imagery belongs to DigitalGlobe/Eurimage for WorldView and QuickBird data, and to GeoEye for Ikonos data.

For virtually all areas assessed in the imagery, with the exception of the Rafah-Egyptian border zone, there was a significant percentage of observed damage possibly caused by IDF ground activity.

For the whole of Rafah Governorate, a total of 943 individual damage sites were identified during the conflict period of 27 December 2008 to 18 January 2009. For Izbet Abed Rabbo neighborhood a total of 374 separate damage sites were identified, while the number for Samouni Street area was 158 separate damage sites and for Al Atatra area 178 separate damage sites were identified.

For the whole of the Gaza Strip, an estimated total of 187 greenhouse complexes were either destroyed or severely damaged, representing a total complex area of approximately 30.2ha. The spatial distribution of this destruction is concentrated in specific areas of Gaza. Approximately 69% of the total affected greenhouse area for Gaza was concentrated within the two governorates of Gaza and Gaza North. The temporal distribution of greenhouse damage in Gaza during *Operation Cast Lead* also reveals a concentration of damage during the last week of the conflict (11-18 January 2009). An estimated 25.8ha of greenhouses were damaged or destroyed during this last period, representing over 85% of all identified damage during the conflict.

Significant damage to industrial facilities was observed in the imagery. The destruction of Sameh al Sawafeary Chicken farm, Namar wells and Abu Jubba cement factory was evident



in the imagery. Based on the detailed image assessment, the only visible damage detected to the Al-Badr flour complex was to the southernmost building. It is important to note that because of the angle of satellite imagery acquisition, it is possible that severe damage has occurred on the non-imaged side and thus is not detectable in the imagery.



## Background

Following a request from OHCHR to support the United Nations Fact Finding Mission on the Gaza, as established by the President of the Human Rights Council, Ambassador Martin Ihoeghian Uhomibhi, pursuant to Resolution S-9/1 of the Human Rights Council (HRC), UNITAR's Operational Satellite Applications Programme (UNOSAT) assessed specific geographical areas and thematics related to the work of the Fact Finding Mission. The overall objective of UNOSAT's work was to provide factual information on the time at which certain buildings were damaged and quantitative assessments of the damage caused to certain types of facilities.

Prior to this request, at the onset of the Israeli military *Operation Cast Lead* (from 27 December 2008 to 18 January 2009), UNOSAT initiated mapping and a satellite-based damage assessment survey over the whole of the Gaza Strip in support of ongoing UN humanitarian operations in the field. This assessment was conducted during and immediately after *Operation Cast Lead* using a time series of very high resolution commercial satellite images acquired on 6, 10, 16, 19 & 21 January 2009. Pre-conflict satellite imagery from 27 September 2005 and 14 June 2007 were also used for baseline analysis.

Because of cloud cover and incomplete satellite coverage, some of the dates cited above provided only partial coverage over Gaza. Some governorates of Gaza were assessed with a minimum of 2 image dates (e.g. Rafah) while others were assessed with up to 4 image dates (e.g. Gaza City and Gaza North). Please see figure 1 for a detailed overview of the coverage dates and locations.

Following the end of the conflict on 18 January 2009, UNOSAT released final damage assessment figures with the understanding that the results had yet to be validated on the ground as part of a comprehensive field assessment. Publically released during the UN-sponsored international donors' conference in Sharm El-Sheikh, Egypt, 2 March 2009, the report findings were as follows:

A total of 3,840 individual damage sites were identified across the Gaza Strip; of this total there were 2,692 destroyed or severely damaged buildings; 187 Greenhouse complexes covering an estimated area of 30.2ha were destroyed or severely damaged; 220 separate impact craters were identified on roads, leaving an estimated length of 167km roads severely damaged; and over 710 separate impact craters (measuring upwards of 20m in diameter) in empty or cultivated fields, potentially affecting around 2,100ha of land.

The extensive UNITAR/UNOSAT geodatabase compiled during the original damage assessment of January –February 2009 was in turn used as the foundation for new and specific analysis on a number of detailed site locations as part of the OHCHR investigation into *Operation Cast Lead*. The requested specific analysis results are presented in detail in this report.

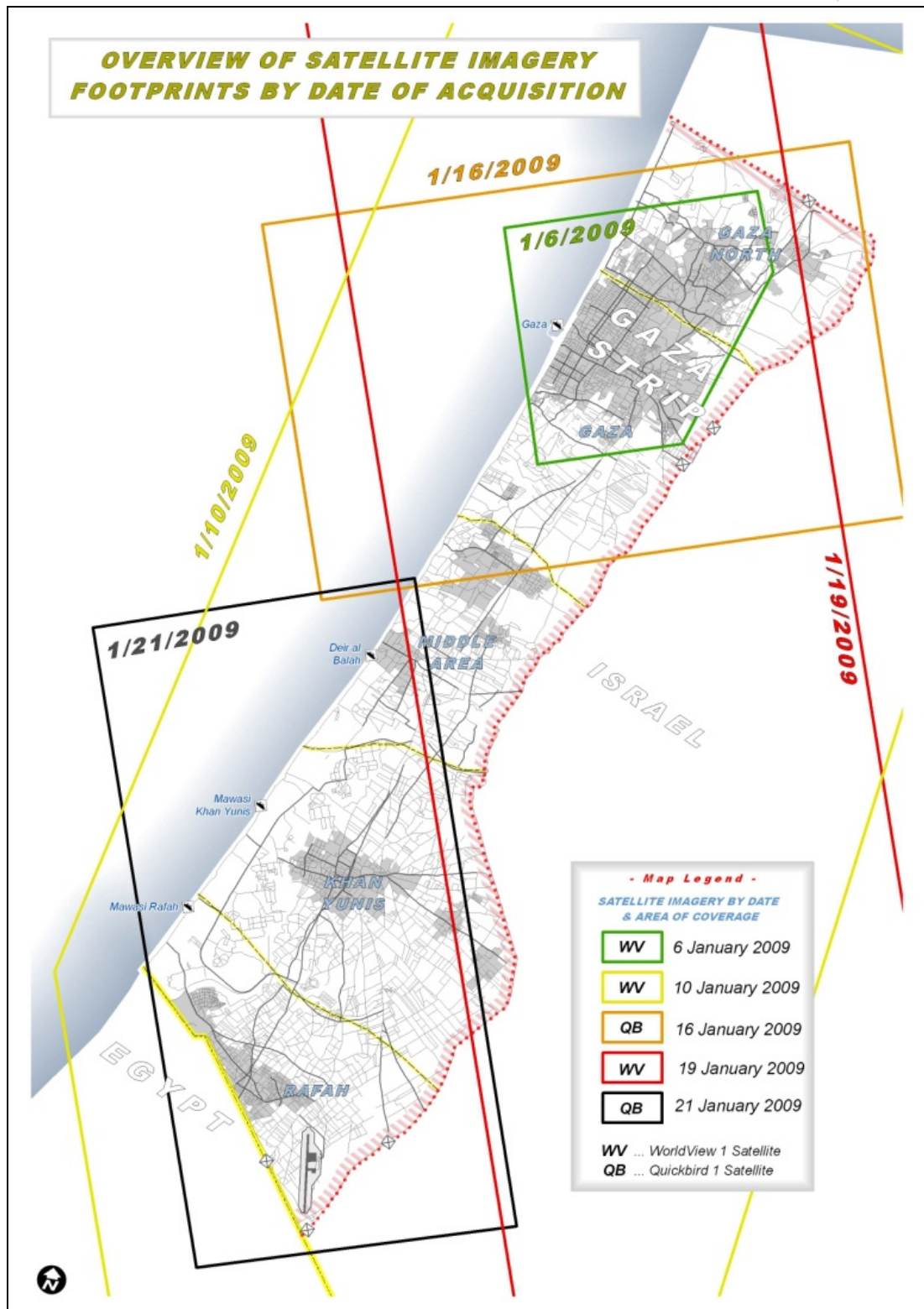


Figure 1: Acquisition dates and coverage for satellite imagery used in this report.



## Methodology

The central assessment methodology was to compare crisis with pre-crisis satellite imagery using standard image interpretation techniques to identify a range of significant damage to buildings, industrial and transport infrastructure, as well as to agricultural resources (e.g. greenhouses and cultivated lands).

Affected buildings were classified either as destroyed or severely damaged, along with a basic confidence interval. Destroyed buildings were generally defined by the total collapse of the structure or when it was standing but with less than 50% of the roof still intact. Severely damaged buildings were defined as having visible structural damage to a portion of one wall, or where less than 50% of the roof was damaged. Buildings identified as having 'no visible damage' did not mean the buildings were undamaged, only that *none were identified with the available satellite imagery and the inherent limitations due to acquisition date, cloud-cover, spatial resolution (level of details) and incidence angle.*

Following the Israeli-Lebanon war of 2006, UNOTAR/UNOSAT conducted a detailed ground survey of multiple sites in Lebanon, to assess the relative accuracy of the satellite-based damage assessment conducted at the time. The ground survey results indicated that severe building damage were identified with a very high degree of success (90-95%), with only one false-positive identified out of several hundred damage sites evaluated. The same general methodology used in 2006 has been used in the assessments reported on in this document.

Equally significant, the survey indicated that the satellite-based assessment was generally unable to identify buildings with light to moderate levels of damage commonly resulting from oblique tank fire or rocket-propelled grenades (RPGs), especially when the damaged buildings were located in complex, high density urban environments. This limitation is, in effect, a fundamental constraint of the spatial resolution of commercially-available satellite imagery. As new sensors offer increasingly higher resolutions (e.g. now 50cm), the damage identification success rate will correspondingly improve.

Considering these basic findings from Israeli-Lebanon war of 2006, there are two additional possible sources of error in this damage assessment for Gaza which need to be specifically acknowledged. First and foremost, because of existing U.S. law, commercially-available very high resolution satellite imagery recorded over Israel and the Palestinian Territories must be degraded in image quality to approximately 2 meter spatial resolution, thus significantly reducing the confidence level for damage identification, especially within dense urban areas. It is highly probable, therefore, that the damage identified in Gaza underestimate the actual building and infrastructure damage present on the ground at the time of satellite image acquisition. *The final damage figures presented below thus represent minimum estimates. Actual damages were likely to be greater.*

Secondly, from field verifications in 2006, it was found that some infrastructure had been destroyed *after* the date of the image used as pre-event baseline data, but *prior* to the post-event image used for comparative damage assessment. To control errors caused from these relatively rare sources of false positives, secondary effects from destroyed infrastructure, such as debris and damage to nearby agriculture, were closely assessed. Typically, debris resulting from a destroyed or damaged building are cleaned up or spread out over a wider area as time goes by. Damaged agriculture areas are repaired for production. Hence, only



infrastructure destruction with surrounding secondary effects indicating recent damage, i.e. piles of debris or fresh damage to agricultural land visible in the post-event imagery, are identified as caused during the recent event.

It should also be mentioned that this is a technical assessment using only commercially available satellite imagery, and so the results can be double-checked by other entities, thus ensuring an objective and transparent methodology.





## **Results**

The results from this analysis focus on time-stamping destruction and providing likely causes and level of the observed damage. The following sections contain the resulting assessments for Rafah, North Gaza neighbourhoods (Izbet Abed Rabbo, Samouni Street, Al Atra), greenhouses in Khuzaa and other areas, as well as industrial facilities (Al Badr flower mill, North Gaza Sawafeary chicken farm, Abu Jubba cement company and Namar wells).



### *Rafah damage assessment*

For the whole of Rafah Governorate, a total of 943 individual damage sites were identified during the conflict period of 27 December 2008 to 18 January 2009. Of this total, 739 buildings were destroyed or severely damaged, 20 greenhouse complexes were destroyed, 43 impact craters were identified on main roads, and a further 141 impact craters were identified on bare soil or cultivated lands.

The damage analysis for Rafah was based on a time series of crisis imagery recorded on 10 and 21 January 2009, thus dividing the analysis into two distinct periods: 1) the first 15 days of *Operation Cast Lead* (27 December 2008 to 10 January 2009), and 2) the last 8 days from 11 -18 January 2009.

As illustrated in Figure 2 (IAF & IDF Areas of Operations) damage sites detected in Rafah have been classified by type, and date period of detection. The overall damage statistics provided above for Rafah Governorate are unevenly distributed in time and are highly spatially clustered into two distinct areas, the primary concentration along the Egyptian border, within the general vicinity of the Philadelphi Corridor; and the second clustered in the eastern border region with Israel, between the Sofia and Darb Al-Masri roads.

Figure 2 also represents the approximate operational zones of the IAF and IDF as inferred from the damage signatures detected in the satellite imagery and cross-checked, when possible, with UN field reports. Based on an analysis of the impact craters identified in the satellite imagery from 10 and 21 January 2009, it is likely that damage within the Philadelphi Corridor area of Rafah City were caused by IAF air strikes and not IDF ground activity. In contrast, there are distinct signatures of IDF tank and heavy vehicle traffic on the ground in the eastern damage zone of Rafah Governorate.

As shown in figure 3, not only do the ground signatures include tank tracks across cultivated fields and paved roads, but also a Star of David measuring 60m in diameter carved into the soil likely by IDF vehicles. It is important to note that this pattern was created during the first week of the IDF ground incursion into Gaza, sometime between 3-10 January 2009. Based on this analysis, it is probable that building damage within this area of Rafah Governorate were likely caused by a combination of IAF air strikes and IDF ground fire.

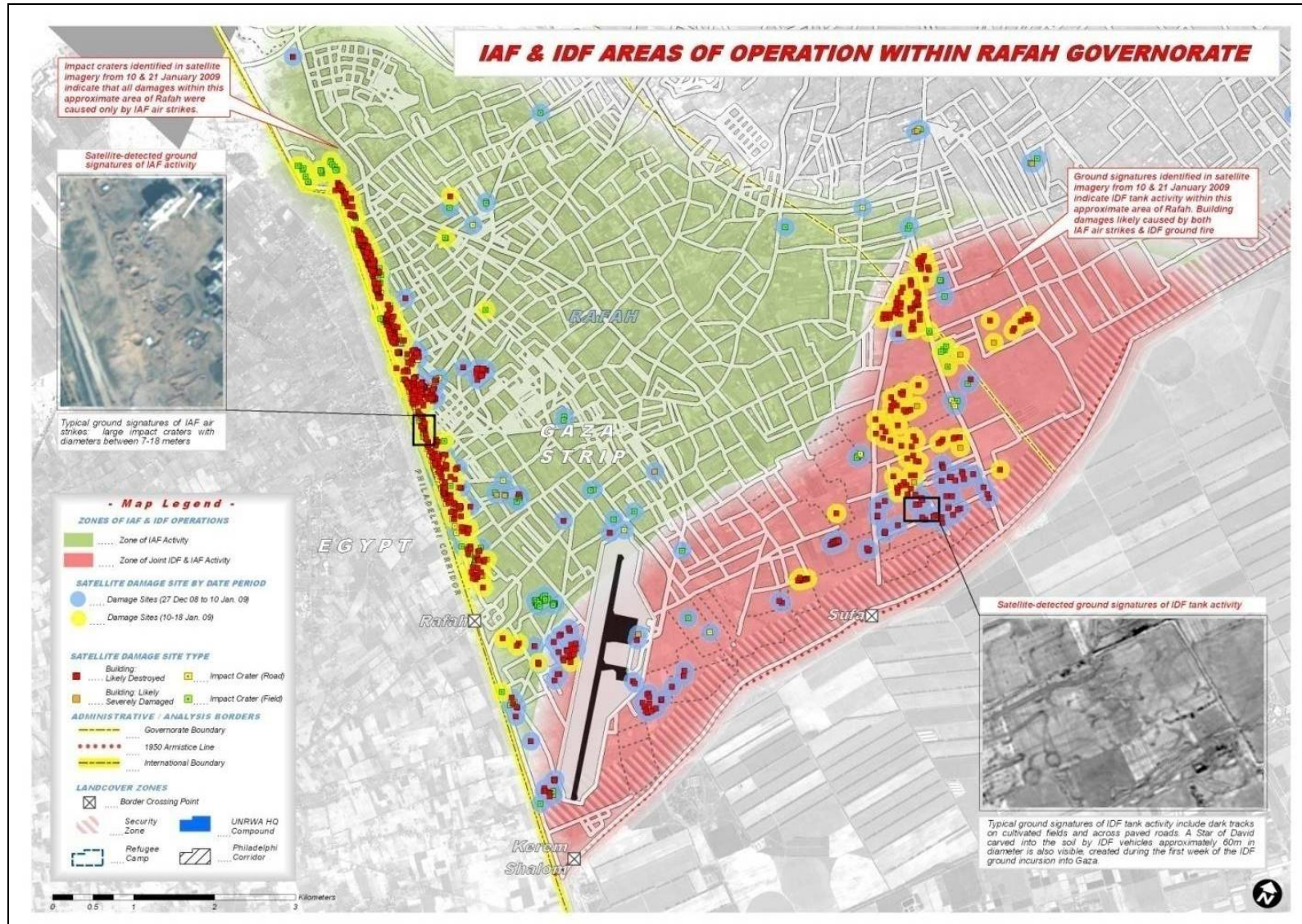


Figure 2: Approximate zones of IAF and IDF areas of operation within Rafah Governorate.

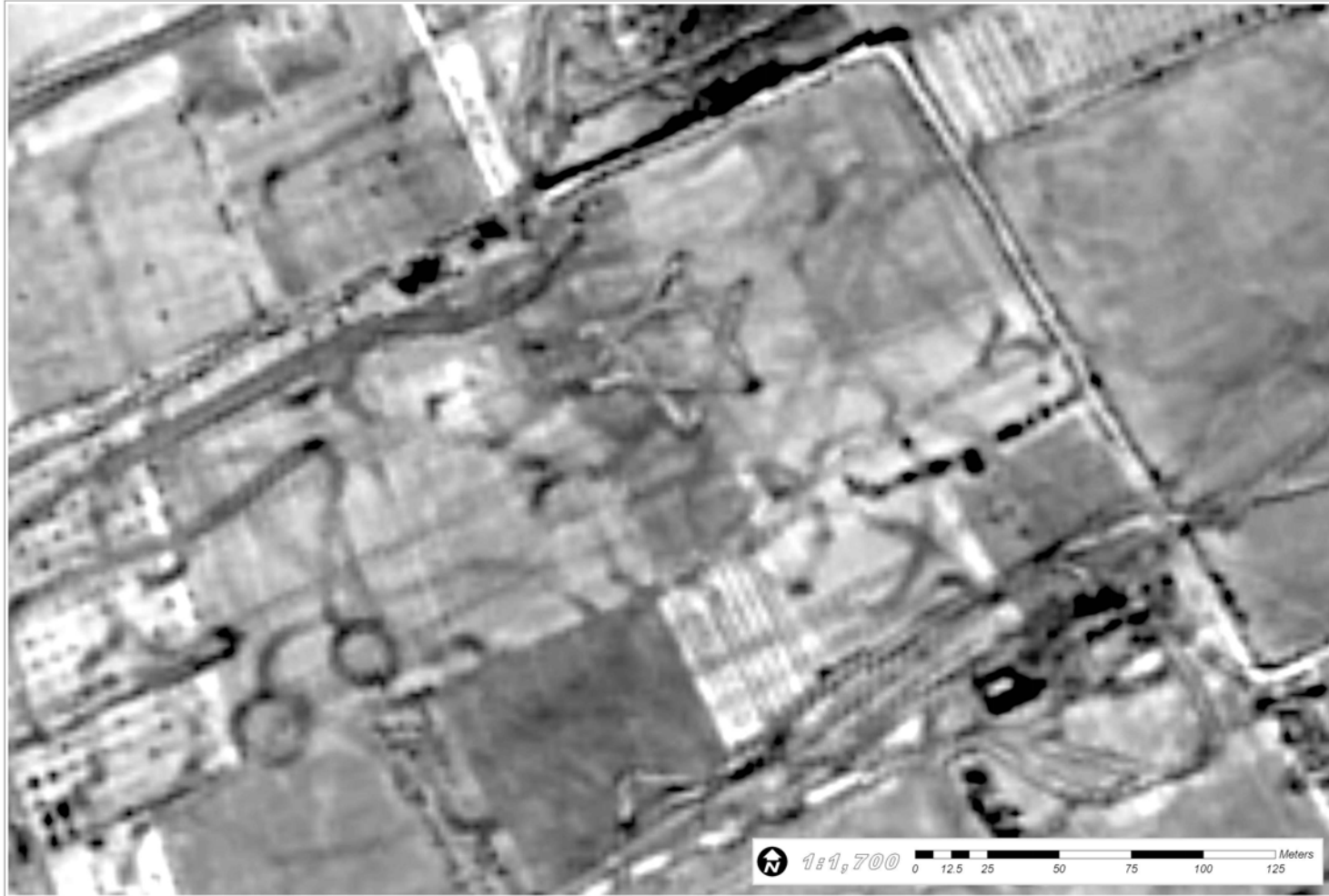


Figure 3: Star of David and other patterns carved into the soil



### Rafah Border with Egypt

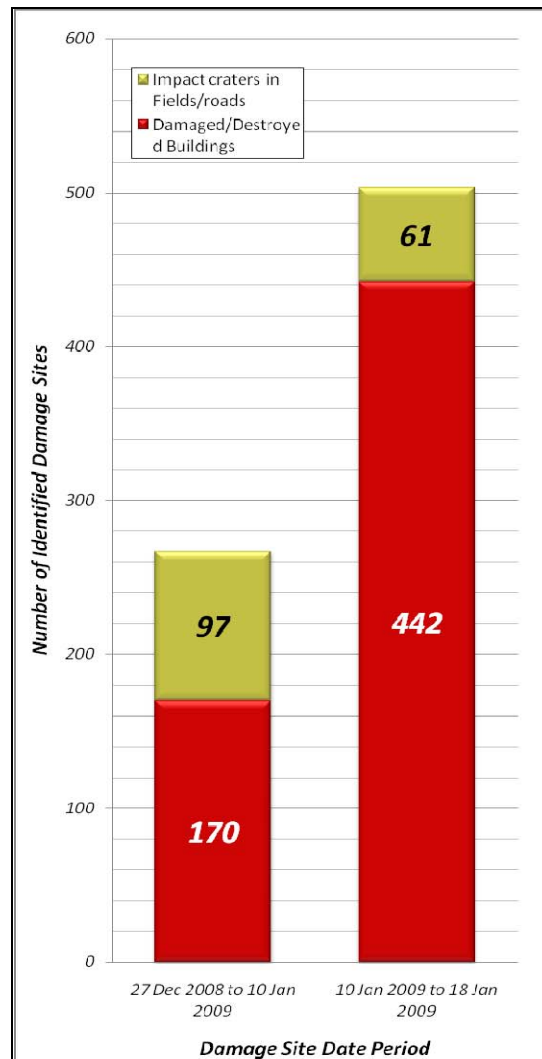
Focusing on the main damage zone within Rafah along the Egyptian border, there are multiple spatial and statistical measurements that help to illustrate the probable military objectives of and changes in IAF targeting during *Operation Cast Lead*.

As illustrated in table 1 and graph 1, during the first period from 27 December 2008 to 10 January 2009, a total of 267 damage sites were identified, representing 34% of the total damage sites identified within 2km of border by the end of the conflict. Of these damages, 170 buildings were targeted during this time, representing 62.9% of all damage sites, with the remaining sites located on roads or fields. During the second period between 11 -18 January 2009, the number of newly detected damage sites increased to 503, 87.8% (442) of which were building targets. By way of comparison, the daily average of new damage sites for the first period was 17.9, in contrast with the daily average of 62.9 new damage sites for the second period 11 -18 January 2009<sup>1</sup>.

*Table 1: Number of Identified Damage Sites within 2km of Egyptian Border, Sorted by date and type*

<b>Damage Site Date Period</b>	<b>Damaged/Destroyed Buildings</b>	<b>Impact craters in Fields/roads</b>	<b>Total</b>	<b>Percentage of total</b>
<i>27 Dec 2008 to 10 Jan 2009</i>	170	97	267	34.68%
<i>11 Jan 2009 to 18 Jan 2009</i>	442	61	503	65.32%
<i>Total Damage Sites:</i>	612	158	770	

<sup>1</sup> Number of damage sites / period length in days



Graph1: Number of identified damage sites by date period for Rafah border with Egypt

Reviewing the spatial statistics on damage sites between these two assessment periods, table 2 illustrates the differences in the average nearest neighbor distance between damage sites of the two periods. What it indicates is that the spatial clustering of targets with respect to each other during the second period increased sharply.

Table 2: Average Distance between the nearest damage sites

Damage Site Date Period	Average Damage Site Distance to Nearest Neighbor (m)
27 Dec 2008 to 10 Jan 2009	42
10 Jan 2009 to 18 Jan 2009	24

A more advanced spatial measurement of this same clustering trend over time is shown in figure 4, which depicts standard deviational ellipses (SDE) calculated for each of the two



damage site periods<sup>2</sup>. A comparison between the two zones indicates that IAF airstrikes between 27 December 2008 and 10 January 2009 were concentrated in a broad elliptical zone along the Egyptian border, with the mean center of strikes south-east of Rafah city center. In contrast, the SDE of IAF airstrikes between 11 and 18 January 2009 contracted sharply into a narrow target zone along border, with the mean center of damage shifted to the north by 2km, inside the Rafah refugee camp.

A further measurement of this change is contained in table 3, indicating that the distance of damage sites to the Egyptian border fell from an average of 580 meters during the first period to 148 meters in the second period.

*Table 3: Mean Distance to Egyptian Border (meters) by Damage Site Type*

<b>Damage Site Date Period</b>	<b>Buildings</b>	<b>Fields/roads</b>	<b>Total average</b>
<i>27 Dec 2008 to 10 Jan 2009</i>	626	502	580
<i>10 Jan 2009 to 18 Jan 2009</i>	140	211	148

Based on these spatial statistics, there is reason to believe that the IAF targeted air strikes against underground tunnels within the Philadelphi Corridor, typically on the main road and empty fields through the Corridor, leaving adjacent buildings generally intact. Buildings which were hit during the first period in Rafah were more broadly distributed across the city, with a mean distance to the border of 626 meters.

The second period was marked by a sharp increase in the total number of damage sites, targeting almost exclusively buildings directly along the border with Egypt. It was found that 72% of all buildings damaged or destroyed within 2km of the Egyptian border occurred during the last week of *Operation Cast Lead* (11- 18 January 2009). Figure 5 presents a detailed illustration of this shift in IAF targeting.

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<sup>2</sup> SDE is an analysis measurement of the average spatial distribution and orientation of point datasets).

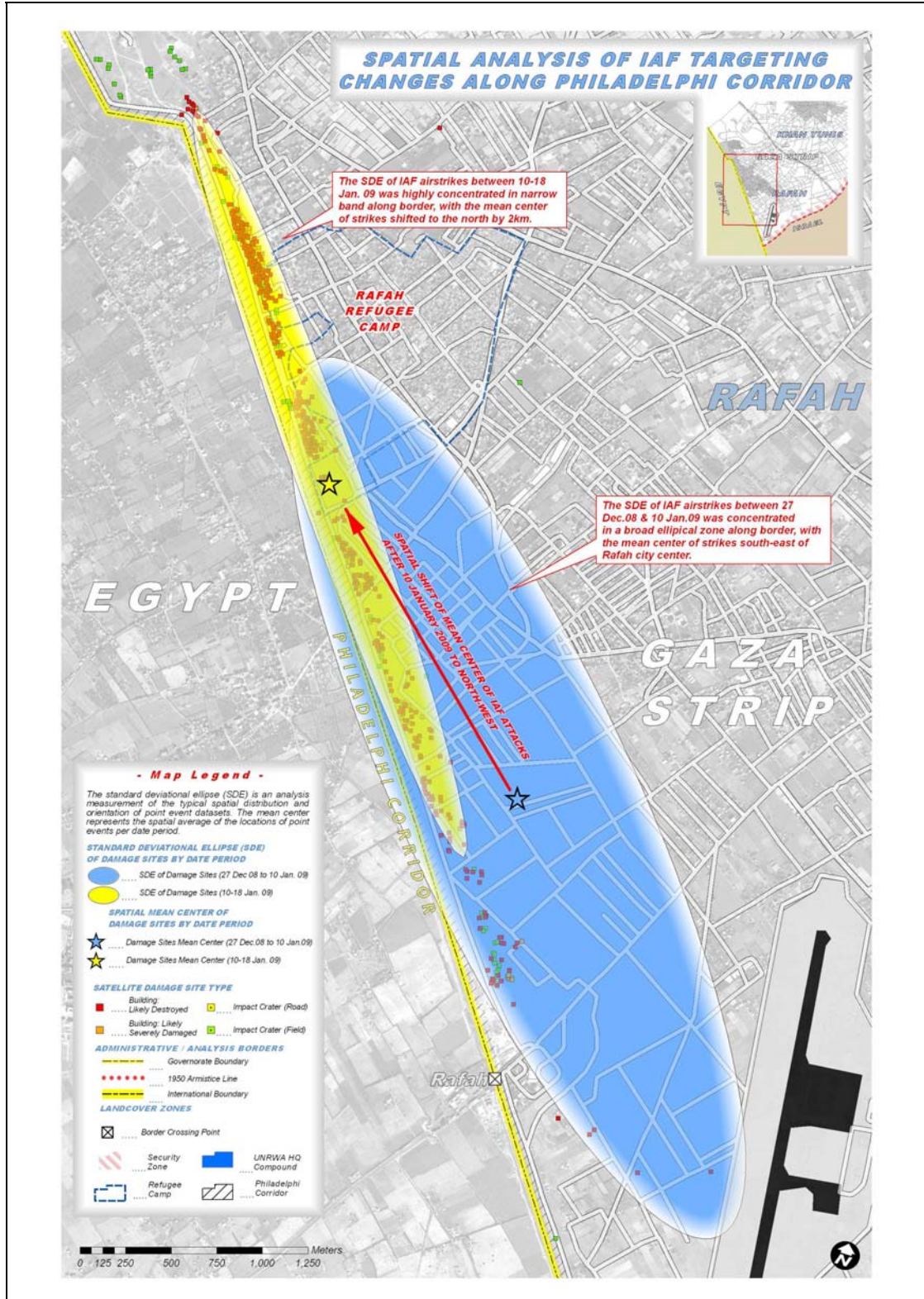


Figure 4: Targeting changes between the date periods along Philadelphih corridor



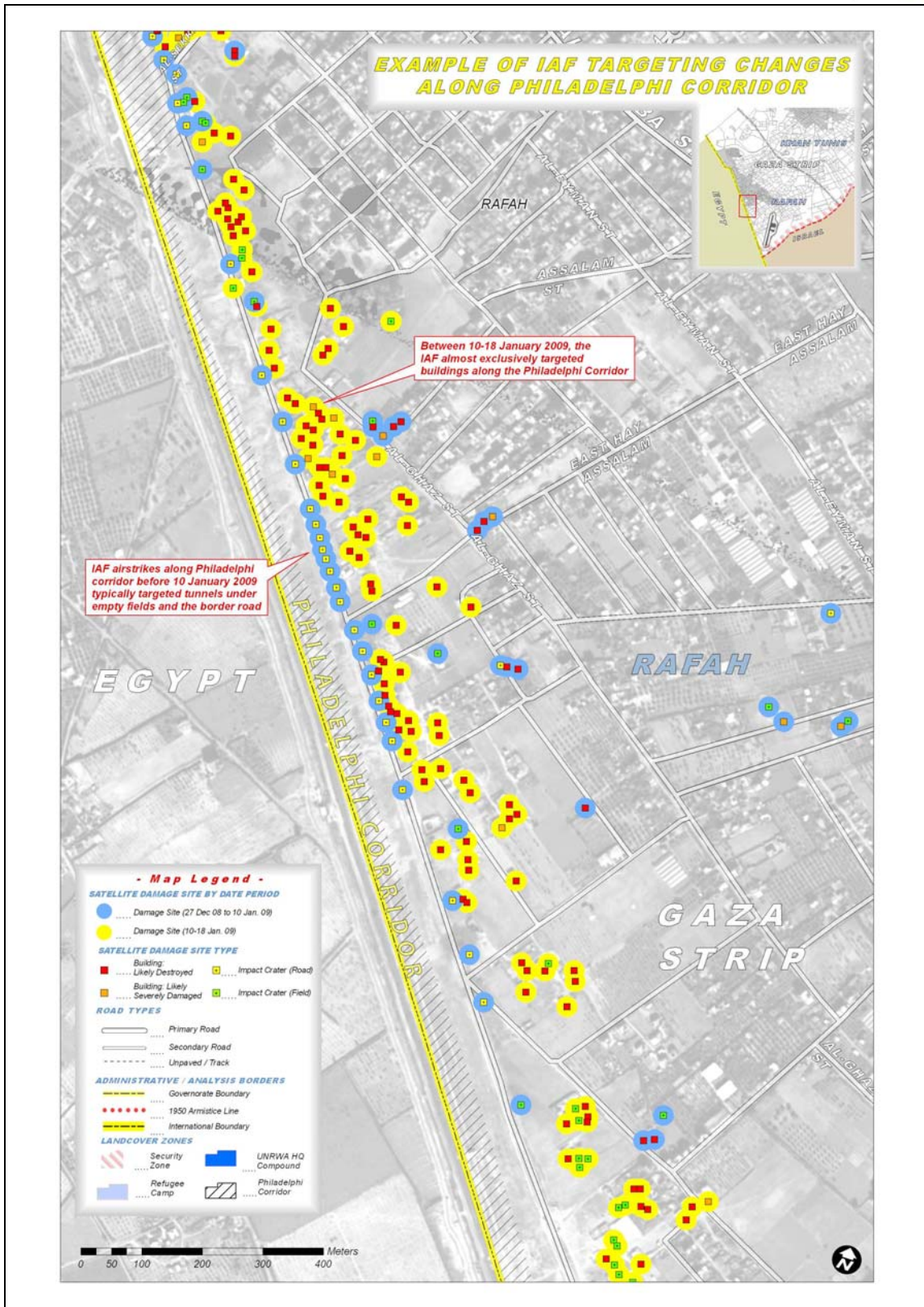


Figure 5: Detailed illustration of shift in targeting along Philadelphi corridor



## *Gaza neighbourhoods damage assessment*

### *Izbet Abed Rabbo area*

There were a total of four separate crisis satellite images captured over the general area of Izbet Abed Rabbo neighborhood (along the border between Gaza and Gaza North Governorates) from 6, 10, 16 and 19 January 2009, allowing for a detailed time-series damage analysis. The final damage assessment at the end of *Operation Cast Lead* included a total of 374 separate damage sites. Of this total, 341 were destroyed or severely damaged buildings, with the remaining 33 impact craters along roads or in cultivated fields.

Further, it was estimated that approximately 12.3km of roads had been severely damaged from a combination of intense IAF shelling and IDF tank movement on the ground. As the time series in table 4 and graph 2 illustrate below, the majority of building destruction occurred between 6 and 10 January 2009, when an estimated 190 buildings were either destroyed or severely damaged, representing 55.7% of all affected buildings in the area during the conflict.

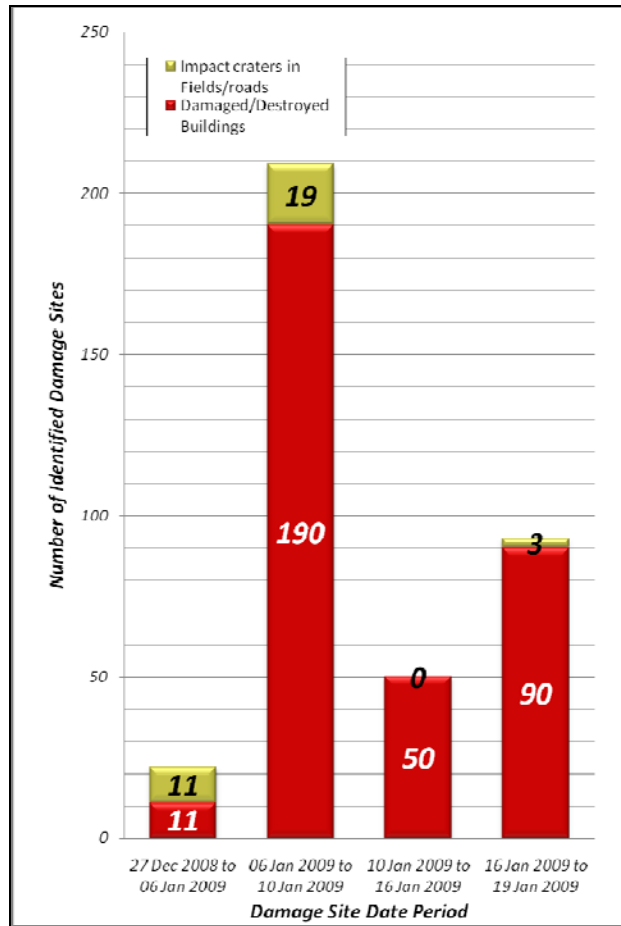
There are multiple signatures of major IDF tank movement on the ground in this neighborhood, and it is probable that identified building damage were likely the result of a combination of IAF air strikes and IDF ground fire.

Please note that because of the absence of clearly defined boundaries for this area within Gaza, a rectangular border was approximately defined over the central portion of Izbet Abed Rabbo, used to define the damage summary statistics provided below. Clearly this represents a source of potential error in reporting damage statistics, and thus could change the reported damage figures with differently defined neighborhood boundaries.

Figure 6 shows an overview of the Izbet Abed Rabbo neighborhood damage assessment.

*Table 4: Number of identified damage sites within Izbet Abed Rabbo area sorted by date and type*

<b><i>Damage Site Date Period</i></b>	<b><i>Damaged/Destroyed Buildings</i></b>	<b><i>Impact craters in Fields/roads</i></b>	<b><i>Total</i></b>
<i>27 Dec 2008 to 06 Jan 2009</i>	11	11	22
<i>06 Jan 2009 to 10 Jan 2009</i>	190	19	209
<i>10 Jan 2009 to 16 Jan 2009</i>	50	0	50
<i>16 Jan 2009 to 19 Jan 2009</i>	90	3	93
<b><i>Total Damage Sites:</i></b>	<b>341</b>	<b>33</b>	<b>374</b>



Graph 2: Graphical representation of number of identified damage sites within Izbet Abed Rabbo area sorted by date and type

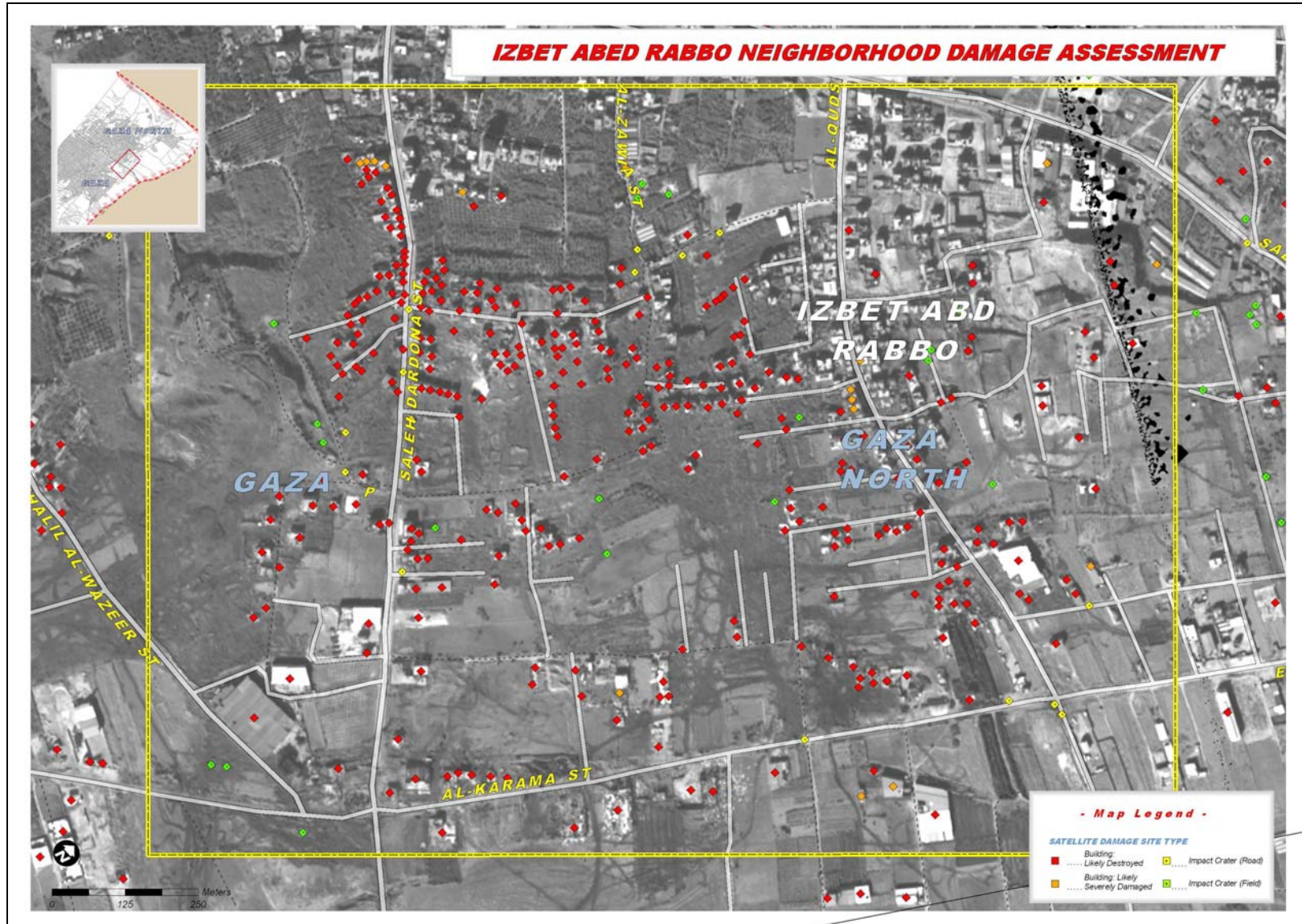


Figure 6: Overview of the Izbet Abed Rabbo neighborhood damage assessment



### Samouni Street area

There were a total of three separate crisis satellite images captured over the Samouni Street Area, within Zeitoun, Gaza Governorate, from 10, 16 and 19 January 2009, allowing for a time-series damage analysis of three conflict periods. The final damage assessment at the end of *Operation Cast Lead* included a total of 158 separate damage sites. Of this total, 114 were destroyed or severely damaged buildings, with the 27 damaged greenhouse complexes, and 17 impact craters along roads or in cultivated fields.

Further, it was estimated that approximately 7.5km of roads had been severely damaged from a combination of intense IAF shelling and IDF tank movement on the ground. As the time series in table 5 and graph 3 illustrate below, the majority of building destruction occurred between 27 December 2008 and 10 January 2009, when an estimated 60 buildings were either destroyed or severely damaged, representing 52.6% of all affected buildings in the area during the conflict.

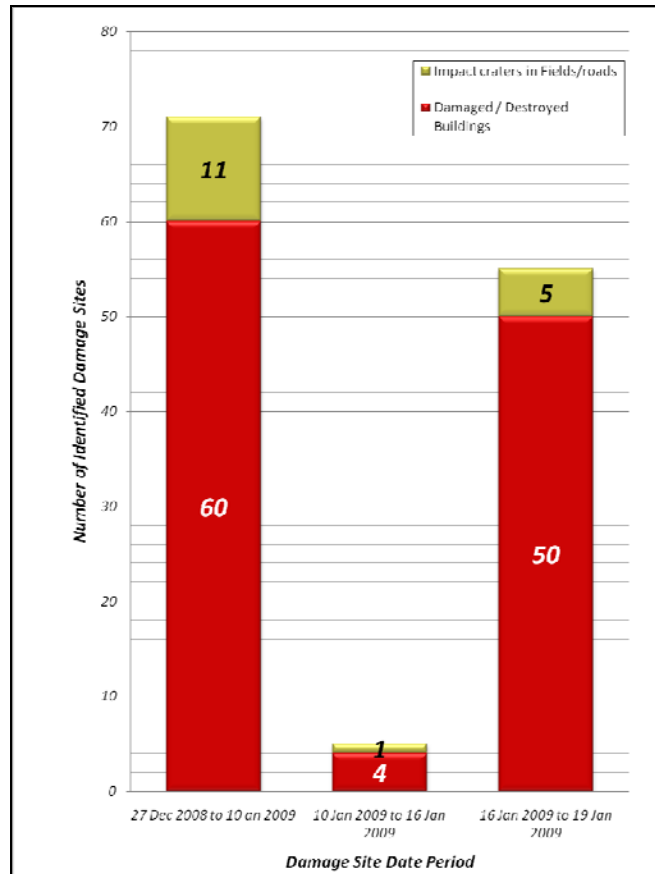
There are multiple signatures of major IDF tank movement on the ground in this neighborhood, and it is probable that identified building damage were likely the result of a combination of IAF air strikes and IDF ground fire.

Please note that because of the absence of clearly defined boundaries for this area within Gaza, a rectangular border was approximately defined over the central portion of Samouni, used to define the damage summary statistics provided below. Clearly this represents a source of potential error in reporting damage statistics, and thus could change the reported damage figures with differently defined neighborhood boundaries.

Figure 7 shows and overview of the Samouni Street neighborhood damage assessment.

*Table 5: Number of identified damage sites within Samouni Street area sorted by date and type*

<b><i>Damage Site Date Period</i></b>	<b><i>Damaged / Destroyed Buildings</i></b>	<b><i>Impact craters in Fields/roads</i></b>	<b><i>Greenhouses</i></b>	<b><i>Total</i></b>
<i>27 Dec 2008 to 10 an 2009</i>	60	11	16	87
<i>10 Jan 2009 to 16 Jan 2009</i>	4	1	1	6
<i>16 Jan 2009 to 19 Jan 2009</i>	50	5	10	65
<b><i>Total Damage Sites:</i></b>	<b>114</b>	<b>17</b>	<b>27</b>	<b>158</b>



Graph 3: Graphical representation of number of identified damage sites within Samouni Street area sorted by date and type

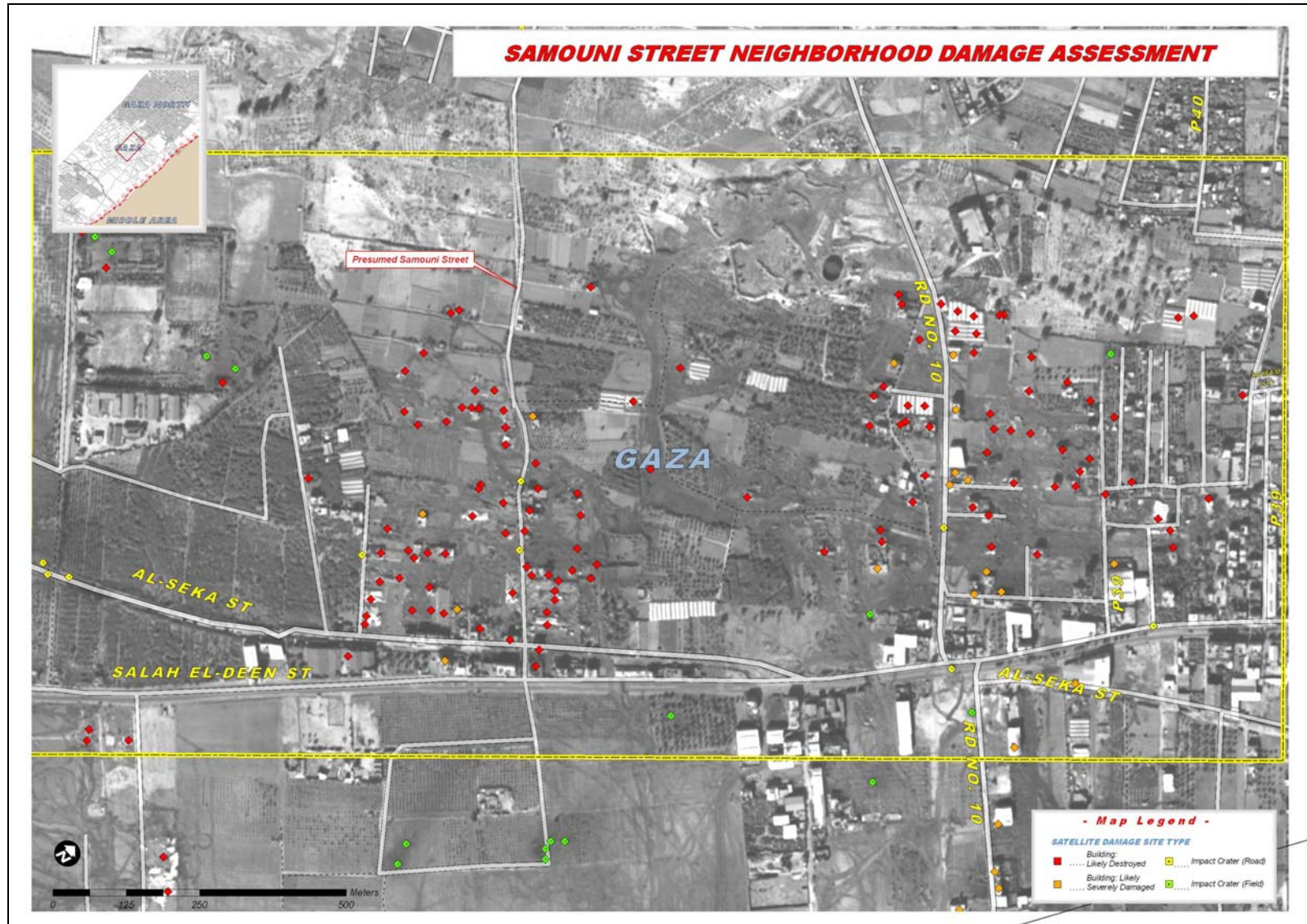


Figure 7: Overview of the Samouni Street neighborhood damage assessment



### Al Atatra area

There were a total of three separate crisis satellite images recorded over the Al Atatra area, west of Beit Lahiya, North Gaza Governorate, from 10, 16 and 19 January 2009, allowing for a time-series damage analysis of three conflict periods. The final damage assessment at the end of *Operation Cast Lead* included a total of 178 separate damage sites. Of this total, 94 were destroyed or severely damaged buildings (including the destruction of the American International School in Gaza), with 43 damaged greenhouse complexes, and 41 impact craters along roads or in cultivated fields.

Further, it was estimated that approximately 4.8km of roads had been severely damaged or destroyed from a combination of intense IAF shelling and IDF tank movement on the ground. As the time series in table 6 and graph 4 illustrate below, the majority of detected damage sites (91) were identified between 27 December 2008 and 10 January 2009. These sites included the destruction of the American International School, as well as multiple impact craters situated within densely populated areas of the neighborhood measuring up to 20 meters in diameter.

There appears to have been a reduction in the newly identified damage sites between 10 and 16 January with only 22 detected. This increased apparently in the last few days of the conflict, between 16 and 18 January 2009, when an estimated 52 buildings were either destroyed or severely damaged, representing 55.3% of all affected buildings in the area during the conflict.

There are multiple signatures of major IDF tank movement on the ground in this neighborhood, and it is probable that identified building damage were likely the result of a combination of IAF air strikes and IDF ground fire.

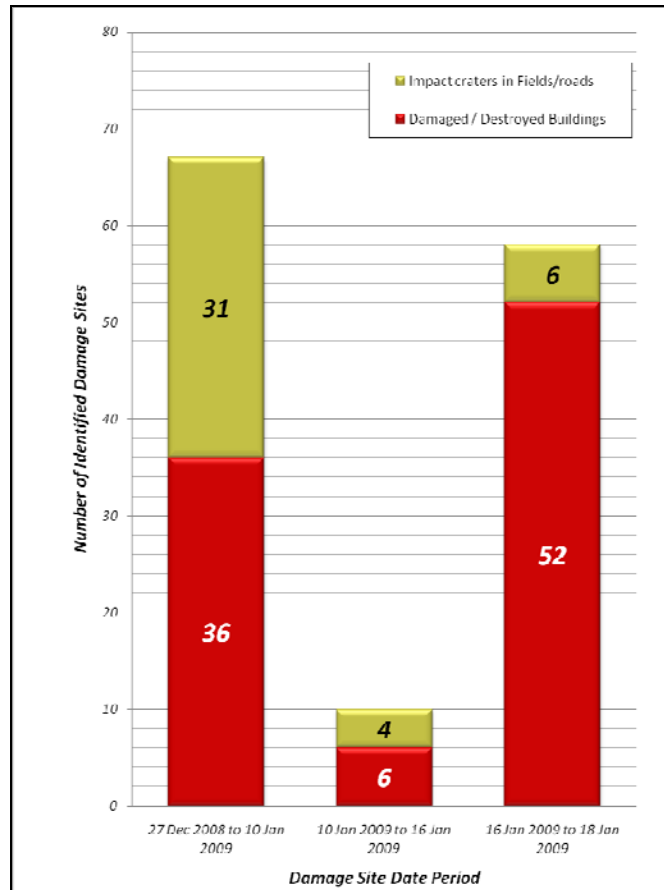
Please note that because of the absence of clearly defined boundaries for this area within Gaza, a rectangular border was approximately defined over the central portion of Al Atatra, used to define the damage summary statistics provided below. Clearly this represents a source of potential error in reporting damage statistics, and thus could change the reported damage figures with differently defined neighborhood boundaries.

Figure 8 shows and overview of the Al Atatra neighborhood damage assessment.

*Table 6: Number of identified damage sites within Al Atatra area sorted by date and type*

<b><i>Damage Site Date Period</i></b>	<b><i>Damaged / Destroyed Buildings</i></b>	<b><i>Impact craters in Fields/roads</i></b>	<b><i>Greenhouses</i></b>	<b><i>Total</i></b>
<i>27 Dec 2008 to 10 Jan 2009</i>	36	31	24	91
<i>10 Jan 2009 to 16 Jan 2009</i>	6	4	12	22
<i>16 Jan 2009 to 18 Jan 2009</i>	52	6	7	65
<b><i>Total Damage Sites:</i></b>	<b>94</b>	<b>41</b>	<b>43</b>	<b>178</b>





Graph 4: Graphical representation of number of identified damage sites within Al Atatra area sorted by date and type

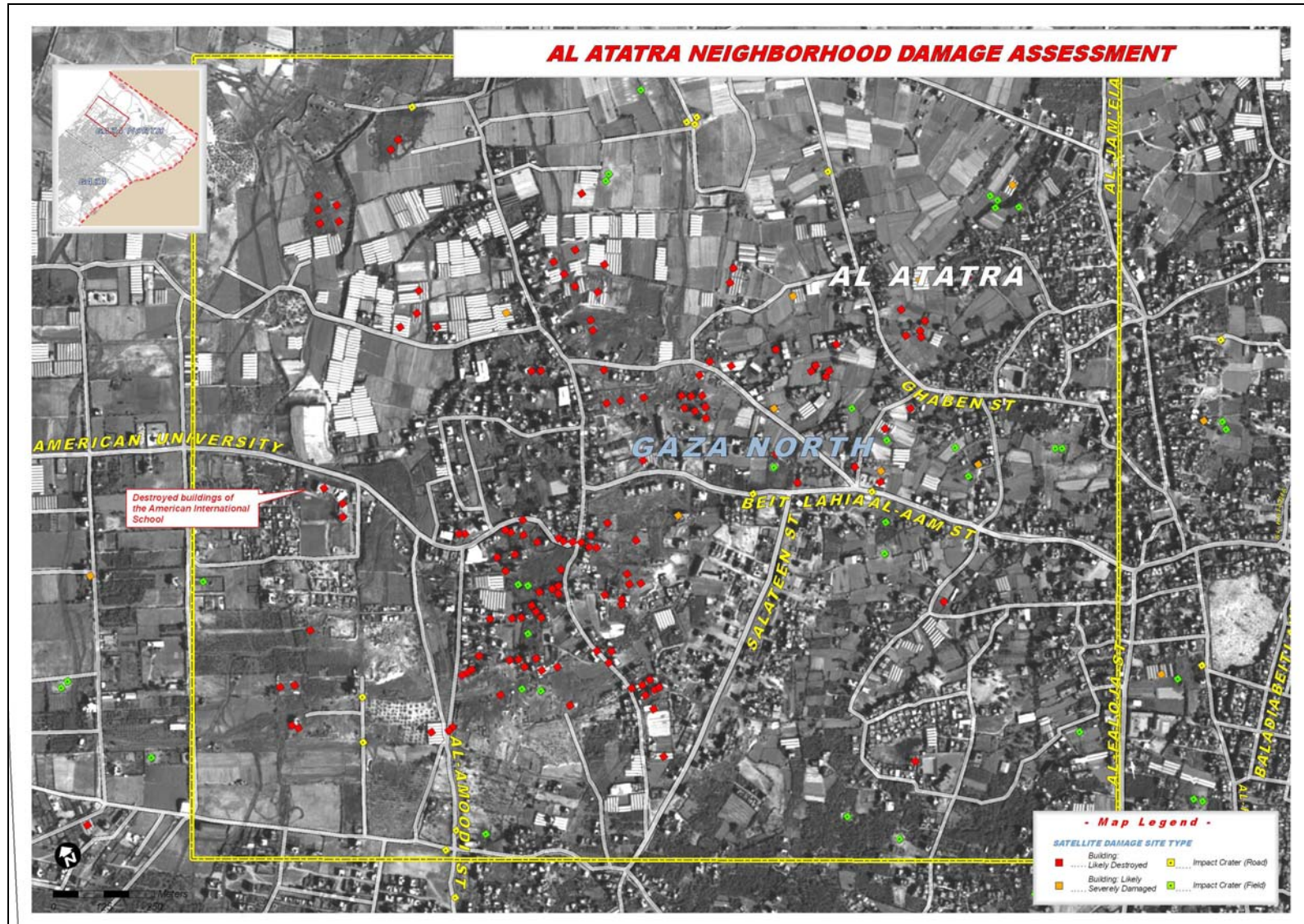


Figure 8: Overview of the Al Atatra neighborhood damage assessment



## Greenhouses

For the whole of the Gaza Strip, an estimated total of 187 greenhouse complexes were either destroyed or severely damaged, representing a total complex area of approximately 30.2ha. As illustrated in figure 9, the spatial distribution of this destruction is concentrated in specific areas of Gaza. Table 7 contains a breakdown of affected greenhouse area (ha) by governorate. The table indicates that 68.6% of the total affected greenhouse area for Gaza was concentrated within the two governorates of Gaza and Gaza North.

*Table 7: Total area (ha) of damaged / destroyed greenhouses by Governorate*

<b>Governorate</b>	<b>Area (ha)</b>
<i>Gaza North</i>	<i>9.5</i>
<i>Gaza</i>	<i>11.2</i>
<i>Middle Area</i>	<i>1.1</i>
<i>Khan Yunis</i>	<i>3.7</i>
<i>Rafah</i>	<i>4.7</i>
<b>Total affected area</b>	<b>30.2</b>

The temporal distribution of Greenhouse damage in Gaza during *Operation Cast Lead* also reveals a concentration of damage during the last week of the conflict. Table 8 divides the total affected area of greenhouses into two date periods. As shown in the table, an estimated 25.8ha of greenhouses were damaged or destroyed during this last period, representing over 85% of all identified damage during the conflict.

*Table 8: Total area (ha) of damaged / destroyed greenhouses by date period*

<b>Date Period</b>	<b>Area (ha)</b>	<b>Percent of total</b>
<i>27 December 2008 to 10 January 2009</i>	<i>4.4</i>	<i>14.6%</i>
<i>10 - 18 January 2009</i>	<i>25.8</i>	<b>85.4%</b>

### *Khan Yunis and Khuza'a Village Focus*

A detailed review of damage in the village of Khuza'a, Khan Yunis Governorate, indicates that a total of 118 damage sites were identified during the course of *Operation Cast Lead*, 92% of which occurred during the last 8 days of the conflict (11-18 January 2009). As illustrated in figure 10, virtually all of the damage sites are located along the eastern edge of the village adjacent to the Israeli security zone along the border with Israel. The total area of damaged or destroyed greenhouses in the village is approximately 2.4ha, representing 8% of all affected greenhouse area in Gaza, and over 65% of all affected greenhouse area in Khan Yunis.

While the absolute area of damaged/destroyed greenhouses in Khuza'a is indeed large, it should be acknowledged that it represents only a small percentage of the total greenhouse area in the village. It was estimated that at the end of the conflict on 18 January 2009, there were approximately 8.1ha of greenhouses in the village with no identified damage, thus representing a greenhouse area damage rate of 23%. Outside of Khuza'a village, there



were 1.3ha of affected greenhouses in the Khan Yunis Governorate, leaving well over 95% of greenhouse complexes intact.

*Damage to Greenhouses by IDF Tanks / Heavy vehicles*

With respect to the probable cause of greenhouse damage in Khuza'a village, and more generally across Gaza, there are strong indications in the satellite imagery that IDF tank and/or heavy vehicles were likely responsible for a major proportion of all greenhouse damage identified in this analysis. The presence on the ground of what is likely multiple tank tracks across cultivated fields and paved roads is strong evidence of IDF ground activity, and in at least one case on the western edge of the Atatra neighborhood, North Gaza, there is a probable tank track running through the center of a destroyed greenhouse complex (see figure 11).

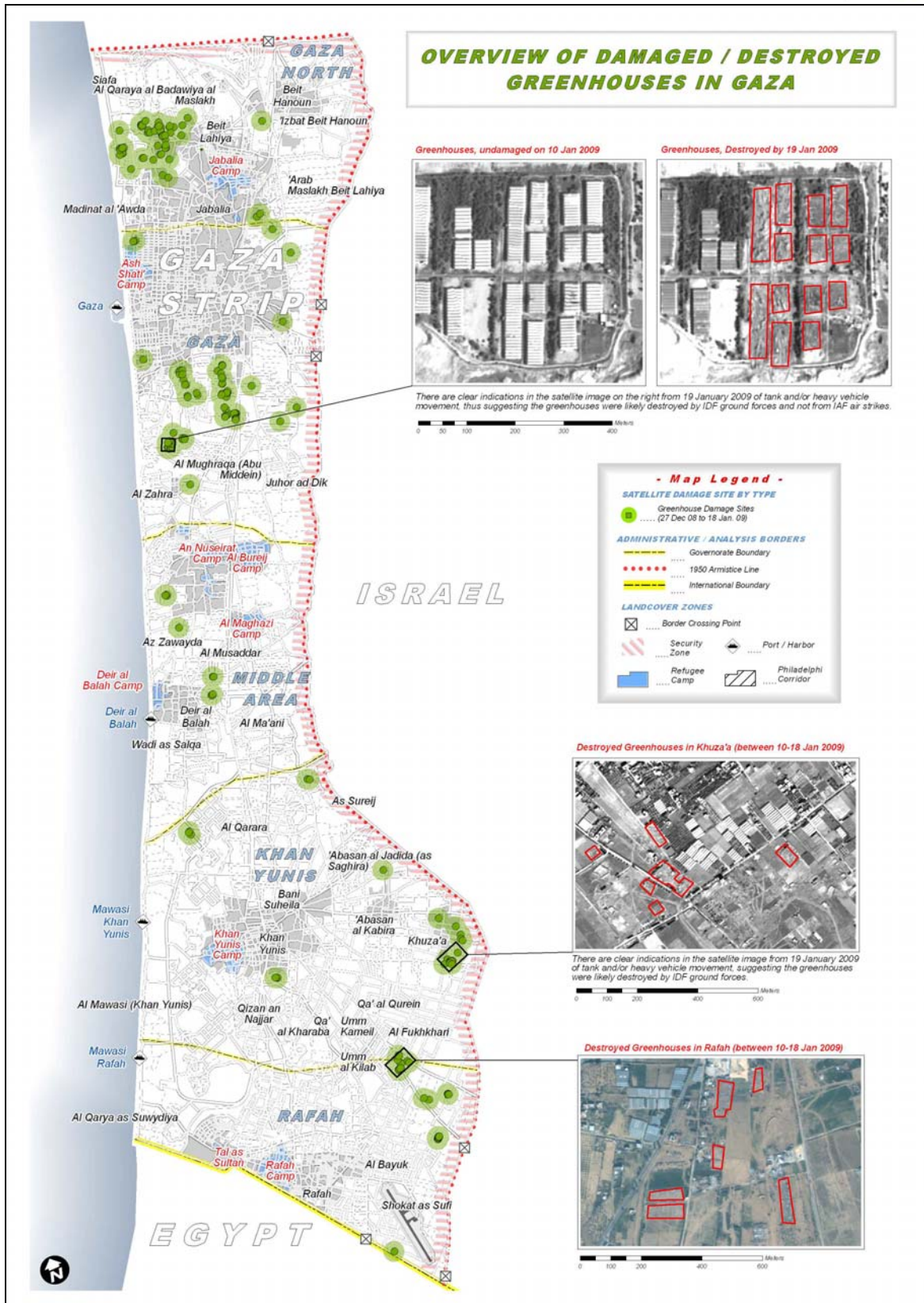


Figure 9: Overview of damaged / destroyed greenhouses in Gaza

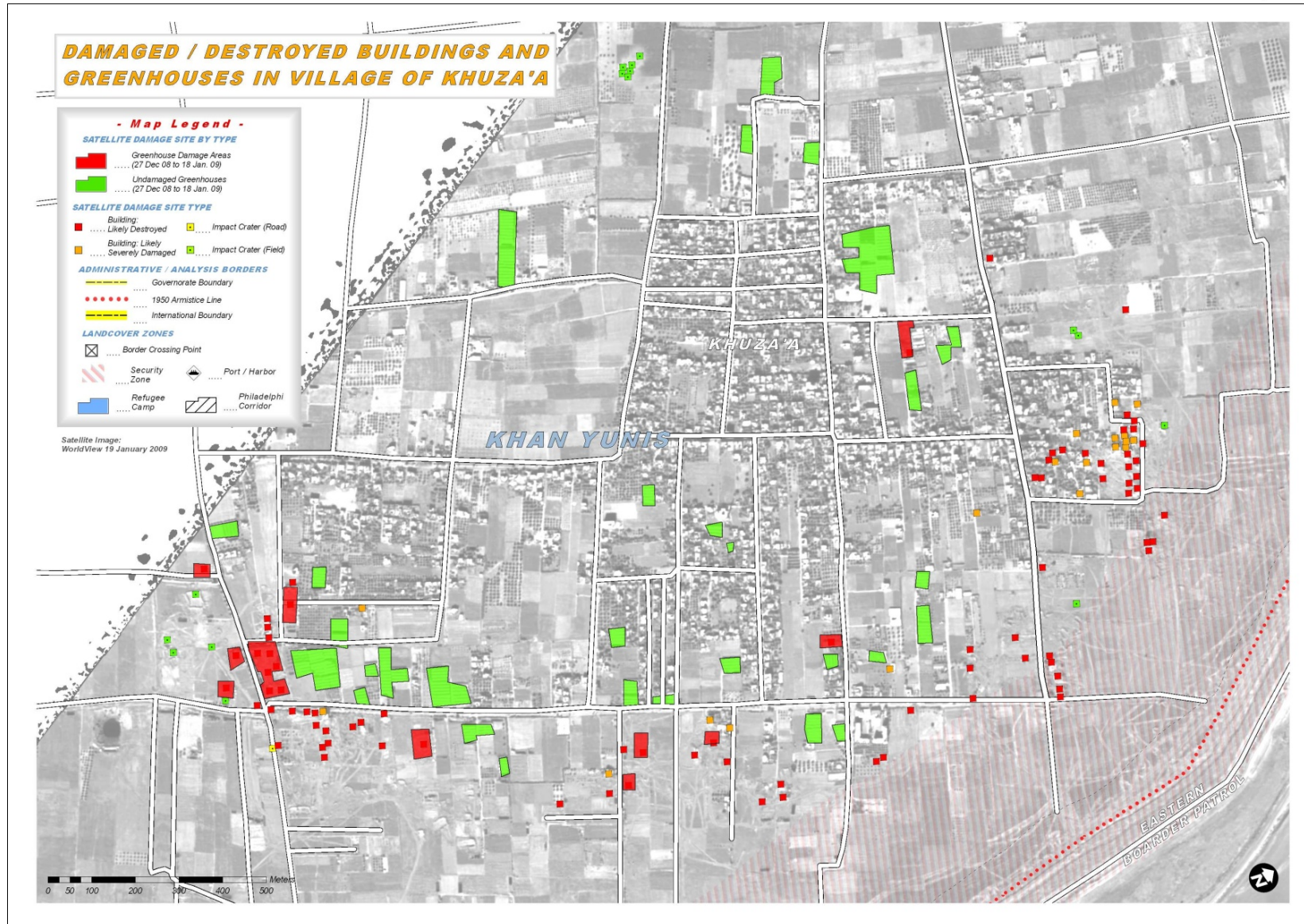


Figure 10: Damaged / destroyed buildings and greenhouses in the village of Khuza'a

**SITE EXAMPLE OF PROBABLE GREENHOUSE DESTRUCTION BY IDF GROUND ACTIVITY IN NORTH GAZA**



Figure 11: Site example of probable greenhouse destruction by IDF ground activity



## *Industrial facilities*

### *Sawafeary chicken farm*

The exact site location of the Sameh al Sawafeary Chicken farm remained undetermined at the time of this report, however a reasonable building complex was identified from the pre-crisis satellite imagery for further analysis. As illustrated in figure 12, the site was located at the correct street intersection (junction of Samouni, al Seka and Salah ed-Deen streets), and which contained five building units similar in shape and size to other medium-scale industrial chicken farms. The buildings were destroyed sometime between 27 December 2008 and 10 January 2009. There are clear signature indications of IDF tank / heavy vehicle movement in and around the immediate vicinity of the buildings, suggesting the strong possibility that these building structures were destroyed by IDF ground forces.

### *Namar wells complex*

The destruction of the Namar Wells complex occurred between 27 December 2008 and 6 January 2009, as identified from the satellite imagery recorded on 6 January 2009. There were a minimum of 5 main destroyed buildings within the complex, and secondary impact craters along Salah el-Deen Street. The largest impact crater identified within the ruins of the complex measured approximately 15 meters in diameter, indicating a likely IAF air strike of considerable magnitude. Within a 500 meter radius of the complex an additional 39 damage sites were identified, including 20 destroyed or severely damaged buildings, the majority of which also occurred on or before the morning of 6 January 2009. There are no specific ground signatures of IDF tank / heavy vehicle movement within the immediate vicinity of the wells complex. See figure 13 for satellite image damage overview of Namar wells complex.

### *Al Badr flour complex*

The Al-Badr Flour Factory of Sudaniyya appears in the satellite imagery to be composed of multiple building sites situated along the north side of El-Bahar Street. Based on the detailed assessment from the imagery, the only visible damages detected to the factory complex are to the southernmost building which was severely damaged along the south-eastern side. The damages appear to have occurred between 16 and 18 January 2009. Within the immediate 500m vicinity of the factory complex there are a total of 43 detected damage sites, including 33 destroyed or severely damaged buildings. The majority of this identified damages occurred between 10 and 18 January 2009. There are clear indications in the imagery of extensive IDF tank movement and related damage to both buildings and vegetation cover in this area during the last three days of the conflict. It is probable, given the damage signatures, that the majority of damage in this area was caused by intense IDF ground fire. It is important to note that because of the angle of satellite imagery acquisition, it is possible that severe damage to the north and eastern side of the flour factory buildings has not been detected. See figure 14 for satellite image damage overview of Al Badr flour complex.





### Abu Jubba cement factory

The Abu Jubba Cement factory, situated along the western side of al-Karama Street, was destroyed between 10 and 16 January 2009. The imagery clearly shows the three main buildings have collapsed. Within the immediate 500m vicinity of the factory complex there are a total of 102 detected damage sites, including 97 destroyed or severely damaged buildings. The majority of these identified damages also occurred between 10 and 16 January 2009. There are clear indications in the imagery of IDF tank movement and related damages to both buildings and vegetation cover, especially north of the cement factory during the last eight days of the conflict. Figure 15 provides an overview of satellite image detected damage of Abu Jubba cement factory.

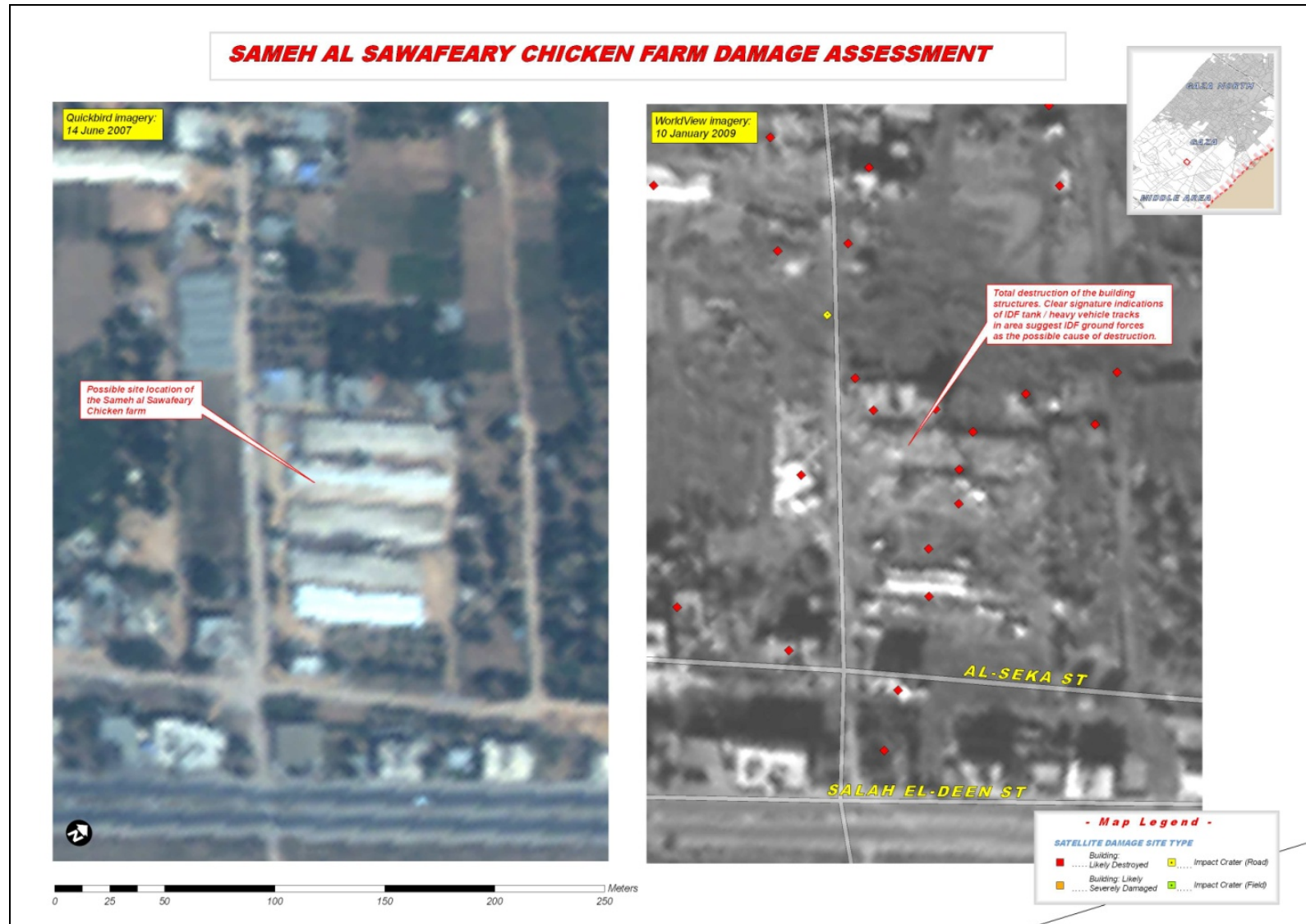


Figure 12: Sawafeary chicken farm damage overview

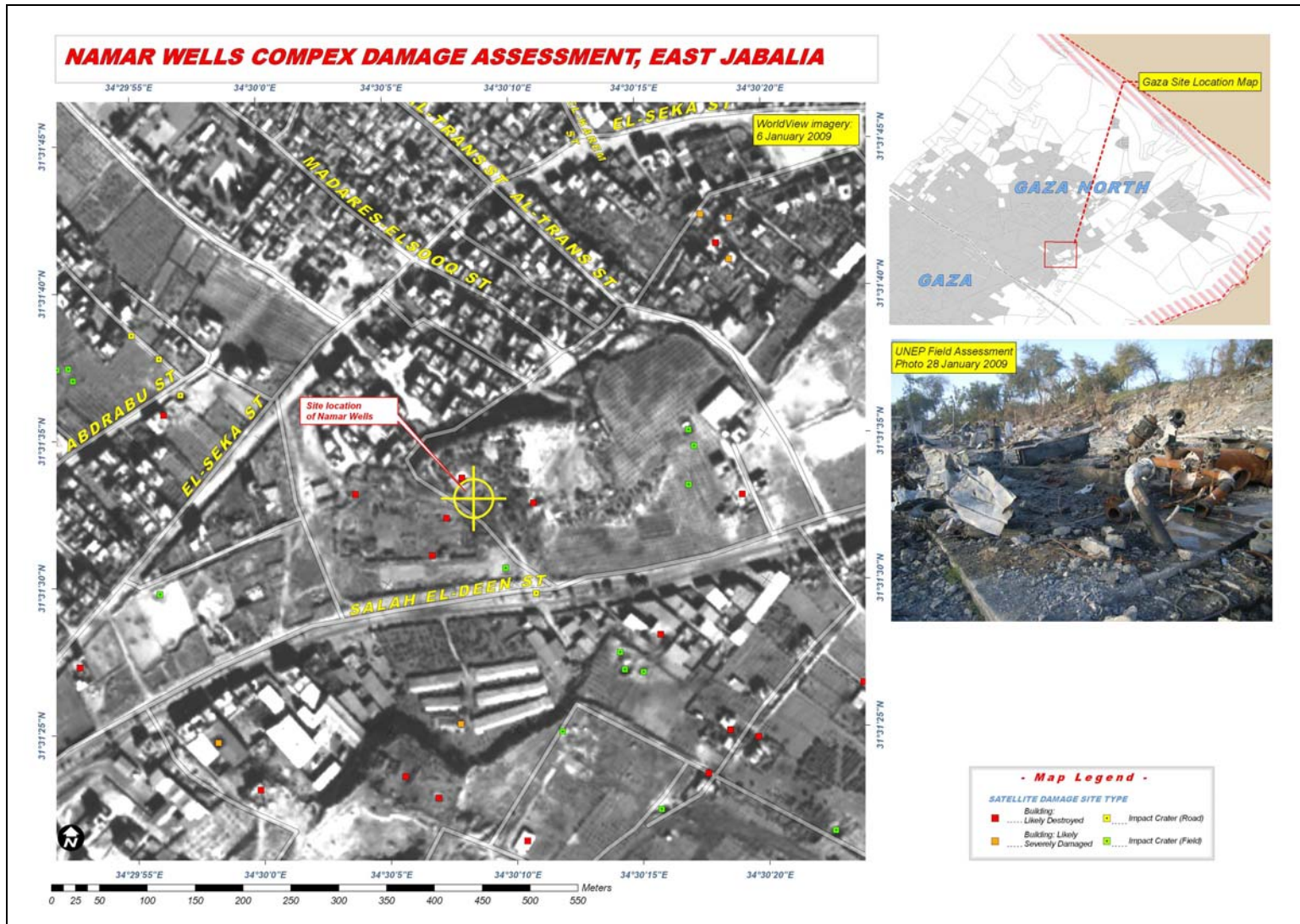


Figure 13: Namar wells complex damage overview

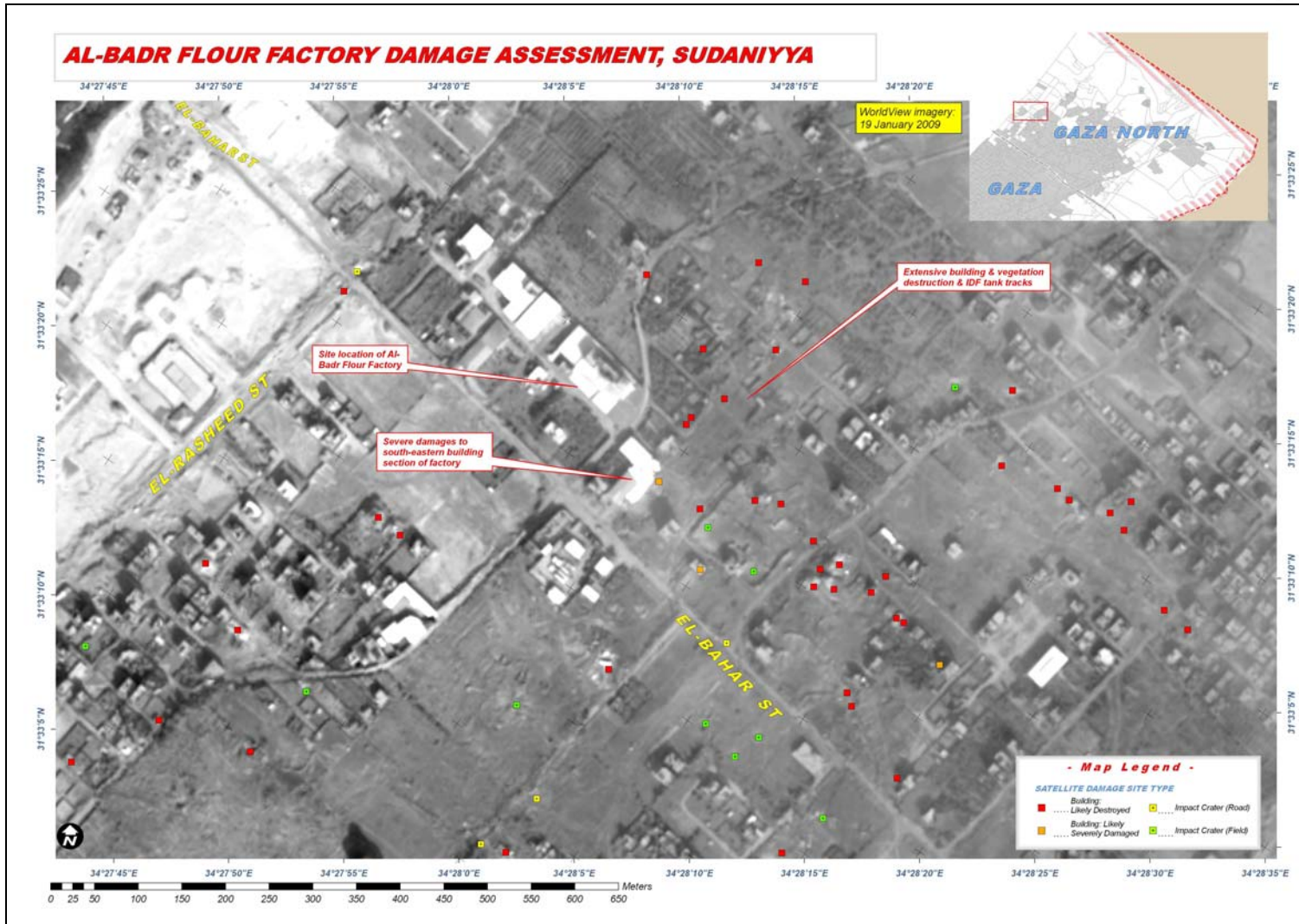


Figure 14: Al Badr flour complex.damage overview

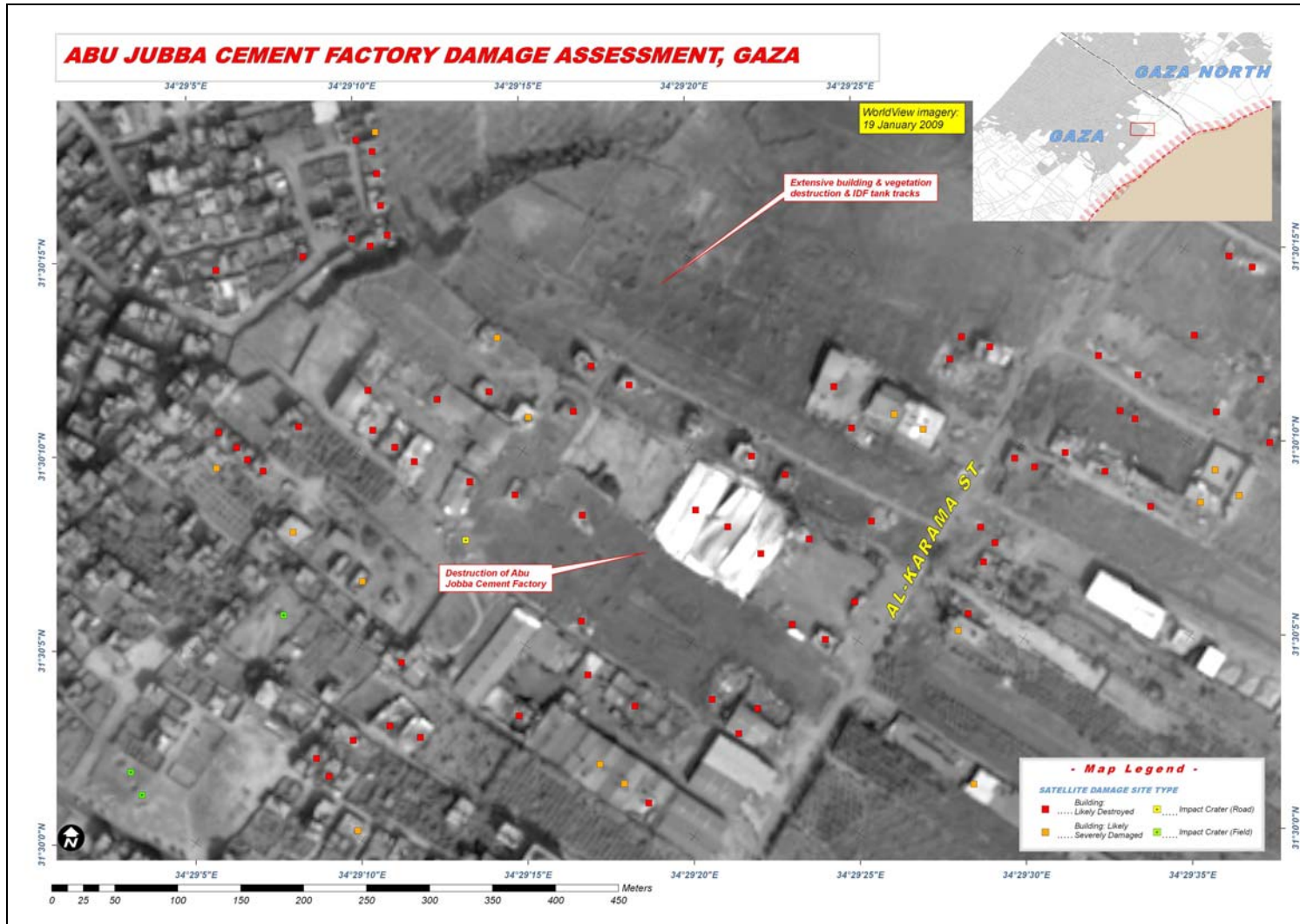


Figure 15: Abu Jubba cement factory damage overview



## Conclusions

The available commercial very high resolution satellite imagery proved to be an essential resource to undertake detailed damage assessments and analyses of destruction patterns, both spatially and temporally. The imagery allowed for time-stamping observed destruction between specific dates and combined with field reports also to draw conclusions on the likely cause of the observed building and infrastructure damage, typically found to be aerial attacks by the IAF or IDF ground forces, including also damage to cultivated land and paved roads.

All geographic and thematic areas requested by OHCHR to conduct focused assessments of have been reported in this document. During the process of undertaking the analysis, it became evident that the use and mainstreaming of geo-positioned data collection in combination with field photographs for human rights assessments adds additional benefit to the interpretation and use of the acquired satellite imagery.

*Acknowledgements: Field photos and Global Positioning System (GPS) co-ordinates used in this assessment have been provided by the OHCHR and UN Environment Programme (UNEP).*



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