Recovery Observatory (RO)

Haiti Hurricane Matthew RO Status and Next Steps

Presentation to WGD #9
Brussels March 14th, 2018

Boby Piard, CNIGS
Agwilh Collet, CNES
Helene de Boissezon, CNES
Jens Danzeglocke, DLR
Deodato Tapete, Francesca Cigna, ASI
Andrew Eddy, RO Secretary
Outline

- Haiti Recovery Observatory
  - Status Overview
  - Feedback after one year
  - December Technical Mission
  - DLR – TerraSAR-X contribution
  - ASI – Terrain motion products
  - Copernicus EMS R&R activations
  - Links with NOAA, ESA, WG CapD
  - Next Steps
- RO concept on other areas
• Triggering of the RO decided by CEOS Chair in consultation with CEOS Principals, December 22, 2016, after Hurricane Matthew - October 2016
• Mission #1 to Haiti - end January 2017 Definition of activities in Haiti
• Mission #2 to Haiti 29 May – 2 June 2017 1st RO users workshop feedback on sample products
• Mission #3 to Haiti 5 Dec - 8 Dec 2017 technical review, link universities
Haiti RO covers three departments: Grand’Anse, Sud, and Nippes.
**RO Timeline**

**Infrastructure**
- Product definition, image requirements

**RO Haiti Triggering**
- 12/22/16

**Missions to Haiti**
- (2 to 3 per year)

**Lessons learned**

**Malawi, Nepal Demonstrators**

**1st User Workshop**
- 29 May – 2 June

**Technical Review**
- 5-8 Dec

**2nd User Workshop**
- 8 – 11 May

**External Mission**

**Hurricane Matthew in Haiti**
- 10/04/16

**Generic RO discussion**
- WB + UNDP DC + NYC (date TBC)
Feedback, involvement and goals

Boby Piard – Head of CNIGS
David Telcy - CNIGS
RO : Hot spot identification
# Thematic coordinators

<table>
<thead>
<tr>
<th>Produit</th>
<th>Key User</th>
<th>First Elaboration</th>
<th>Satellite data</th>
<th>Focal Point</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartography of the building (Jérémie, Les Cayes, route d’Aquins)</td>
<td>CIAT/Ministry of Planning (MPCE)</td>
<td>Copernicus EMS; SERTIT (methodology); CNIGS (production);</td>
<td>Optical THR</td>
<td>Rose-May GUIGNARD</td>
<td>CIAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pierre Alexilien Versaille MPCE/ CNIGS</td>
<td></td>
</tr>
<tr>
<td>Land Use</td>
<td>All (reference data)</td>
<td>CNIGS/CESBIO /SERTIT</td>
<td>Sentinel-2, HR Optical</td>
<td>Jacques Philemon</td>
<td>MPCE / CNIGS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Saint Phar JEAN</td>
<td>MDE/ ONEV</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Ministry of Agriculture (MARNDR)</td>
<td>Copernicus EMS ; CNIGS/SERTIT</td>
<td>Sentinel-2, Optical HR, zoom THR</td>
<td>Ognel PIERRE-LOUIS</td>
<td>MARNDR / DRFS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>David TELCY</td>
<td>MPCE / CNIGS</td>
</tr>
<tr>
<td>State and monitoring of the Macaya Park</td>
<td>ANAP / ONEV (MDE)</td>
<td>Copernicus EMS ; SERTIT</td>
<td>Optical THR, radar THR</td>
<td>Sait Phar JEAN</td>
<td>MDE/ ONEV</td>
</tr>
<tr>
<td>State and monitoring of watersheds</td>
<td>ONEV (MDE) - Ministry of Agriculture (MARNDR)</td>
<td>CIMA Foundation</td>
<td>Digital terrain model 1m/20cm and Radar THR</td>
<td>Jean André PIERRE</td>
<td>MPCE / CNIGS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pradel FORMONVIL</td>
<td>MPCE / CNIGS</td>
</tr>
<tr>
<td>Landslide / Quarry monitoring</td>
<td>BME / Ministry of Public Works (MTPTC)</td>
<td>EOST</td>
<td>Optical HR/THR, Radar TerraSAR-X</td>
<td>Samuel GENEA</td>
<td>MTPTC/ BME</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eric CALAIS</td>
<td>ENS France</td>
</tr>
</tbody>
</table>
Technical Mission:
5 to 8 December, 2017

- Technical Work on each thematic between experts
- Inclusion of Universities
- RASOR training (ONEV, CNIGS, DPC) and RO platform presentation
- Steering committee #2

CNES: Frederic Moll, Agwilh Collet,
SERTIT: Robin Faivre,
CIMA: Giorgio Boni,
RO Secretary: Andrew Eddy

Working Session with ONEV and Health Ministry, December 2017
Technical Mission #1

- Protected natural areas: Macaya Park
- Infrastructure and road communication: 1st -> Jérémie
- Health (New)
- Technical web infrastructure
- Landslides, Seismic risks (with ASI / EOST)
- Watersheds, flooding (with CIMA)

- 7 working session in Haitian offices (CNIGS, CIAT, ONEV, BME…)
- Second loop on several products (Watersheds, Building in Jérémie, Macaya Park)
- Definition of needs on Health thematic
• Strong Haitian presence and support for RO concept

• The university session provided an overview of the training and capacity development needs.

• There is a strong desire to provide additional training in remote sensing, geomatics and more generally on the possible applications of remote sensing.

• A one-day training session on the contribution of geomatics and remote sensing could be organized in the fall of 2018, with preparation for the spring 2018 mission. During the week of the 2\textsuperscript{nd} User Workshop, several small training sessions are being organised.
PRODUCTION SCHEME:

Data used:
- Orthophoto 2014
- Pléiades - 07/10/2016
- Pléiades - 18/10/2017

Input data:
- Building from Copernicus EMSR185 action (polygon with damage)
- Building from Open Street Map (polygon)

Method:

The geometry of the polygons (OSM + previous site) is recalculated compared to that of the orthophoto 2014, which is considered as the absolute reference.
Technical Meeting #1:
Example - Infrastructure around Jérémie

Infrastructure and road communication:
1st -> Jérémie
Technical Meeting #1:  
Example - Infrastructure around Jérémie

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2016</th>
<th>2017</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not affected</td>
<td>Destroyed</td>
<td></td>
<td></td>
<td>3219</td>
</tr>
<tr>
<td>In construction</td>
<td>Destroyed</td>
<td></td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Not existing</td>
<td>Destroyed</td>
<td></td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>Not affected</td>
<td>Damaged</td>
<td></td>
<td></td>
<td>1196</td>
</tr>
<tr>
<td>In construction</td>
<td>Damaged</td>
<td></td>
<td></td>
<td>62</td>
</tr>
<tr>
<td>Not existing</td>
<td>Damaged</td>
<td></td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>Not affected</td>
<td>Not affected</td>
<td></td>
<td></td>
<td>2037</td>
</tr>
<tr>
<td>Destroyed</td>
<td>Not affected</td>
<td></td>
<td></td>
<td>2843</td>
</tr>
<tr>
<td>Destroyed</td>
<td>In construction</td>
<td></td>
<td></td>
<td>111</td>
</tr>
<tr>
<td>Destroyed</td>
<td>Not existing</td>
<td></td>
<td></td>
<td>303</td>
</tr>
<tr>
<td>Not affected</td>
<td>Not affected</td>
<td></td>
<td></td>
<td>5719</td>
</tr>
<tr>
<td>Not affected</td>
<td>Not existing</td>
<td></td>
<td></td>
<td>346</td>
</tr>
</tbody>
</table>

**4 states:**
- Not affected
- In Construction
- Not Existing
- Damaged
- Destroyed

Infrastructure and road communication: 1st -> Jérémie
Technical Meeting #1:
Example - Infrastructure around Jérémie

Infrastructure and road communication:
1st -> Jérémie

Neighborhoods that have access problems
• SPOT 6 image of January 8, 2016
• SPOT 7 image of June 25, 2016
• SPOT 7 image of February 14, 2017
• Use of the 4 Multi-spectrale band at 6m (R-G-B-PIR)
• Taking samples on the ortho-photo of 2014:
  • Treed vegetation (31)
  • Shrub vegetation (32)
  • Vegetation dominated by grass (33)
  • Open space without or with very little vegetation (51)

• Data set for training, a second for validation
• Calculs of NDVI and Shadow Index
• Indices Calculs of texture (Haralick Texture Extraction) : Entropy and Homogénéity (Inverse Different Moment)
• Useful to delate cloud and smooth classification
• Random sampling in the reference database: 2000 points divided according to the proportion of each class
• Crossing with the corresponding R-V-B-PIR-NDVI-SI-ENT-HOM values at the point
Technical Meeting #1:
Example Vegetation monitoring / Macaya Park

January 2016
Technical Meeting #1:
Example Vegetation monitoring / Macaya Park

June 2016
Technical Meeting #1:
Example Vegetation monitoring / Macaya Park

February 2017
2. Preliminary Results

Parc Macaya: 72.06 km²
Bare land: 7.34 km²
High Vegetation: 26.71 km²
Low Vegetation: 35.83 km²
Other: 2.17 km²

2016

2017

Bare land: 6.18 km²
High Vegetation: 30.04 km²
Low Vegetation: 33.73 km²
Other: 2.11 km²
2. Preliminary Results

- No identification of plant species ... but type of vegetation (high and low)

- No cloudless images on this area (clouds on the ridges)

- Loss of information related to cloud shadow, steep slopes

- Need to have a very precise Digital Terrain Model to avoid a geometrical shift between images

- Confusion between bare soil and low vegetation, because dates in the dry season

- Confusion on the shaded slopes => better to work with summer images

- No significant trend between 2016 and 2017
TerraSAR-X contribution to RO

Jens Danzeglocke, DLR
TerraSAR-X acquisition and planning

- Background acquisitions have started in Nov. 2016
- TSX Stripmap data in 3m spatial resolution allows coverage of the complete Haiti AOI in regular intervals

- 5 descending strips and 4 ascending strips have been acquired 3 times until now (4th coverage almost complete)
- Usage of the same satellite orbit with different view angles limits the possible repetition rate…
- Observations will go on (changes in the obs. planning possible)
TerraSAR-X Example

TerraSAR-X acquisition parameters:
StripMap (SM)
Orbit 150 - strip_005
Ascending
HH polarization
Acquisition dates:
- T1: 2016-12-18 22:54:54
- T3: 2017-08-17 22:54:59
- T4: 2018-02-09 22:54:58

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Leading questions for TSX contribution to RO

- General question: can 3m radar data be of help for recovery related issues?
  - relatively coarse images
  + 30km swath width
  + no clouds and cloud-shadows (AOI in humid tropics)

- Change Detection could help identifying recovery-related issues and sub areas of special interest
  - Infrastructure and settlement changes?
  - Agricultural changes?
  - Inland waters / frequently inundated areas?
  - Smaller catastrophic events...

- Meaningful contributions to disaster recovery and reconstruction?
- Valuable synergies using TSX Stripmap together with VHR optical sensors?
ASI-CIMA activities for RO
### CIMA RO work framework

**Planning:**

<table>
<thead>
<tr>
<th>WP1100</th>
<th>WP2100</th>
<th>WP3100</th>
<th>WP4100</th>
<th>WP5100 (ASI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KOM</td>
<td>RA1</td>
<td>RA2</td>
<td>RA3</td>
<td>RF</td>
</tr>
</tbody>
</table>

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| WP1100 | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| WP2100 | ✔ | ✔ |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| WP3100 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| WP4100 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| WP5100 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

We are here

Progetto CEOS DRM

- **WP1100**: Gestione e coordinamento Fondazione CIMA
- **WP2100**: Monitoring of the recovery phase in Haiti (RO)
- **WP3100**: Monitoraggio di selezionati indicatori globali Fondazione Cima
- **WP4100**: Customization of the Rasor platform
- **WP5100**: Management ASI
WP 2100:

• Choice of the AOI

• Change detection algorithm integrating CSK and Pleiades

• Experimentation on case studies, for monitoring post-Hurricane Matthew changes
WP 2100: choice of AOI according to RO database

• Acquisition plan

CSK Archive 2009-2018

Only Spotlight in the period of interest post Matthew
WP 2100: choice of AOI according to RO database

• Acquisition plan

Pleiades RO - 2018

Overlap with CSK archive
Change detection SAR/optical VHR
Preliminary Ex: classification SAR/optical VHR

Case study on Port-au-Prince, Haiti, land cover classification at 2.5 m spatial resolution from a GeoEye-1 RGB image and a COSMO-SkyMed stripmap image

Case study on Port-au-Prince, Haiti, 50 cm spatial coverage land cover classification from an image Pléiades (pansharpened), a COSMO-SkyMed spotlight image and an ultrafine RADARSAT-2 image
Change detection SAR/optical VHR
Preliminary Examples: classification SAR/optical VHR

Case study on Beijing, China, supervised change detection at spatial resolution of 10 m starting from SPOT-5 multi-temporal images
WP4100: activities foreseen

• Implementation in RASOR of flood hazard maps
• Implementation in RASOR of exposure layers
• Modification of the exposure in accordance with the results of WP 2100
• Evaluation of potential damage for certain hazard scenarios deduced from the maps (focus on Flood risk)
Examples of application of the RASOR platform on RO Haiti (Les Cayes)
Terrain motion products based on satellite SAR

ASI‘s Scientific contribution to the RO

Deodato Tapete, ASI
Francesca Cigna, ASI
ASI’s terrain motion products based on satellite SAR

Scientific goals

• Develop experimental scientific products tailored to obtain useful information on ground stability and motions for target areas of the RO

• Test VHR SAR for hotspot mapping via:
  o bespoke COSMO-SkyMed SpotLight campaign in different recovery contexts
  o InSAR processing within ESA Geohazards Exploitation Platform (GEP)

Target areas (stakeholders’ priorities)

• Jeremie (urban + rural)
• Camp-Perrin (rural + road network)
• Carriere Arniquet (rural + mining)
Satellite data → newly acquired ASI’s COSMO-SkyMed X-band data

- 3-year long tailored monitoring campaign [started on 1\textsuperscript{st} Dec 2017]
- SpotLight images at very high spatial resolution (1 m)
- Ascending and descending mode acquisition geometries, 16 days revisit time

More than 50 COSMO-SkyMed SpotLight scenes already acquired for the target areas

~5/6 scenes per site, per geometry

(as of mid March 2018)
ASI’s terrain motion products based on satellite SAR

Methodologies

• SAR interferometry (InSAR) and change detection methods
• Advanced multi-temporal InSAR and landslide motion time series

Assessment of landslide velocity and state of activity

Example of InSAR-based mapping of landslide motion
ASI’s terrain motion products based on satellite SAR

Methodologies

• Advanced multi-temporal InSAR and terrain motion mapping in urban areas
• Geospatial analysis to correlate with natural and anthropogenic hazards

Detection of ground instability in urban environments

Terrain motion mapping with COSMO-SkyMed and correlation with city subsurface and anthropogenic activities

Exploitation of ESA’s Geohazards Exploitation Platform (GEP)

- Testing of hosted processing services available in the GEP
- Both conventional and advanced InSAR methods to detect terrain motion
- Generation of GIS-ready digital products
- Also to be tested with DLR’s TerraSAR-X StripMap scenes
Exploitation of ESA’s Geohazards Exploitation Platform (GEP)

• Submitted GEP project proposal for evaluation by ESA and Terradue
• Project approved on 09/02/2018, activities kicked-off & GEP account setup

➢ Task 1: Ingestion of new SAR data into GEP
  o **COSMO-SkyMed**: regularly uploaded by ASI and ESA onto ESA’s ftp since Feb. 2018
  o **TerraSAR-X**: link with DLR server established by DLR and ESA in Feb. - Mar. 2018
Copernicus EMS support sought in May of 2017. Internal confusion at the World Bank/GFDRR led to long delay in activation. Direct contact taken by CNIGS with EU delegation in January 2018.

Activation now underway:

- **Activation EMSN050 - Post Matthew damage assessment and monitoring of recovery activities in the south region of Haiti.**

- **Activation EMSN051 – post Matthew monitoring on rural areas, south region of Haiti.**
• **This activation covers the following:**
  o General reference content
  o Damage assessment of assets with a focus on buildings in 2 areas of interest (AOI: 1 and 2)
  o Identification of Internally Displacement Person (IDP) camps close to secondary cities (AOI: 1 and 2).
  o Monitoring of reconstruction activities of the assets and monitoring of evolution state of the IDP camps
• **Call is focused on areas around Jeremie and Les Cayes.**
• **Call was released 6th March.** Firms have ten days to respond, and 20 days to deliver product.
• This activation covers the following:
  o Detailed damage assessment of Parc Makaya
  o Monitoring of Parc Makaya rehabilitation and possible illegal logging
  o Agricultural changes, especially in Les Cayes plain
  o Coast zone changes

• Call will be released soon. Firms have ten days to respond, and 20 days to deliver product.
• **NOAA**
  - Interest of NOAA (Felix Kogan NOAA/NESDIS) to provide satellite-based Vegetation Health (VH) products
  - Teleconf organized held to refine haitian needs and organize data acess

• **ESA**
  - Haitian partners should use GEP to process SAR-derived products developed by ASI team
  - Data access through GEP

• **WG CapD**
  - Presentation of RO needs in capacity Building at the last WG CapD Meeting (March 7th)
  - Analysis of WG CapD possible contribution to RO : TBD
Next steps

- RO Capacity Building plan dedicated to develop
  - “RO products” local producers
  - “RO products” local users
- Workshop #2 from May 7 to 11
  - In Port-au-Prince and Les Cayes (local user workshop and awareness activities)
  - Consolidate links with Universities (training during next mission)
- Solicitation of new funding and new partners to augment product and Capacity Building offering
- RO promotion/dissemination
- Development of Generic RO Concept
- Definition of Haiti RO legacy
Satellite support for Risk Management in Haiti – an innovative example

• The event aims to showcase the very rich experience currently underway in Haiti:
  ○ International Charter Authorised User request;
  ○ Hurricane Matthew RO;
  ○ Copernicus Work in Haiti – rapid mapping and risk and recovery;
  ○ RASOR Phase II;
  ○ UNDP Risk Assessment Work;

• Tuesday, 15 May 09:00 – 11:00 in Capilla Room
Satellite support for Risk Management in Haiti – an innovative example

- 9:00  Welcoming Remarks – CNIGS - Boby Piard
- 9:10  Haitian Civil Protection Department and the use of satellite data for hurricane response: the Charter experience – DPC Haiti - Jerry Chandler
- 9:40  UNDP Risk Management activities in Haiti – UNDP - Samira Philip
- 10:10 Early achievements of the RO project – CNIGS - Boby Piard
- 10:30 RASOR (Rapid Analysis and Spatialisation of Risk) in Haiti: an advanced tool for risk assessment and risk information integration – CIMA – Giorgio Boni
- 10:45  Next steps for satellite data exploitation in Haiti: a round table discussion – moderator Andrew Eddy
Outlines

- Haiti Recovery Observatory
  - Status Overview
  - Feedback after one year
  - December Technical Mission
  - DLR – TerraSAR-X contribution
  - ASI – Terrain motion products
  - Copernicus EMS R&R activation
  - Next Steps

- RO concept on other areas
Expressions of interest:

- World Bank in **Nepal**, for assessing the situation of reconstruction after the 2015 EQ - Waiting for Nepal government decision to express needs
- **Vietnam** ministry of agriculture / UNDP / WB / IRD for post typhoons agricultural situation management

**RO concept for post Irma management in France:**

- Further to EMS RMS & Charter activations, decision by CNES to secure Pleiades acquisitions for guaranteeing “Recovery imaging”
- French “Delegation Interministerielle à la Reconstruction” triggered EMS RRM mid February – work to start mid March
- Anticipation by CNES for 1st results “EMS RRM like” at the 5th Committee held March 12th with French Prime Minister
Les moyens : images Pléiades disponibles pour l’évaluation

Lancement par le CNES d’une campagne d’acquisition systématique d’images satellite Pléiades

Passage de l’ouragan Irma sur Saint-Martin

- 06/09/2017
- 08/09/2017
- 10/09/2017
- 11/09/2017
- 12/09/2017
- 13/09/2017
- 14/09/2017
- 23/10/2017
- 25/11/2017
- 30/11/2017
- 18/02/2018
- 02/03/2018
- 03/03/2018
...  

Évaluation de l’impact

Évaluation de la reconstruction

Suivi régulier de la reconstruction

→ fin 2019 (programmation envisagée)

Pléiades, un système d’observation de la Terre :
- 2 satellites français lancés et opérés par le CNES
- très haute résolution (70 cm)
- capacité d’acquisition journalière en tout point du globe
- capacité d’acquisition d’images stéréoscopiques pour la réalisation de modèles numériques de terrain
Que voit-on avec Pléiades ?

Évolution de la situation
Bâtiments endommagés en cours de reconstruction
Sandy Ground (Ouest St-Martin)

Post-Irma, septembre 2017
15 décembre 2017
18 février 2018

Situation avant ouragan
Bâtiments et toits endommagés
Bâtiments reconstruits ou en cours de reconstruction
Situation quasi-stationnaire
**Que voit-on avec Pléiades ?**

Évolution de la situation
Dépôt de gravats / débris
Baie Nettlé (Ouest St-Martin)

**Situation avant ouragan**

Post-Irma, septembre 2017  23 octobre 2017  25 novembre 2017  15 décembre 2017  18 février 2018

Apparition du dépôt de gravats  Réduction du dépôt de gravats  Réduction du dépôt de gravats  Disparition du dépôt de gravats
État du bâti post-Irma septembre 2017

Vue globale de la partie française de Saint-Martin

État du bâti post-Irma (09/2017)

- Détruit
- Fortement endommagé
- Moyennement endommagé
- Peu ou pas endommagé
- Non analysé (couverture nuageuse persistante)

Cartographie au 1:23 000
Echelle de travail : jusqu'au 1:2 000
État du bâti post-Irma, septembre 2017

Nombre de bâtiments cartographiés : 11 254

État du bâti post-Irma septembre 2017

Estimations réalisées par photo-interprétation d’une série d’images satellite Pléiades, acquises entre le 8 et le 14 septembre 2017 (passage de l’ouragan sur St-Martin le 6 sept).

Inexistant à la date d’observation
44
0,39%

Peu ou pas endommagé
5875
52%

Moyennement endommagé
2349
21%

Fortement endommagé
1881
17%

Détruit
1059
10%
État du bâti le 15 décembre 2017

Vue globale de la partie française de Saint-Martin

Suivi de la reconstruction

État du bâti au 15/12/2017

- Déblayé
- Endommagé
- En construction
- Etat normal

Cartographie au 1:23 000
Echelle de travail : jusqu'au 1:2 000
État du bâti post-Irma, 15 décembre 2017

Estimations réalisées par photo-interprétation d’une série d’images satellite Pléiades, acquises pendant les 3 mois suivant le passage de l’ouragan Irma.
THANK YOU!

MERCI!