



DEFENCE AND SPACE

# Surface Movement Monitoring (SMM) based on High-Resolution TerraSAR-X Satellite Data

Operational Case Studies and Latest Developments

Dr. Jan Anderssohn  
5th July 2018

**AIRBUS**

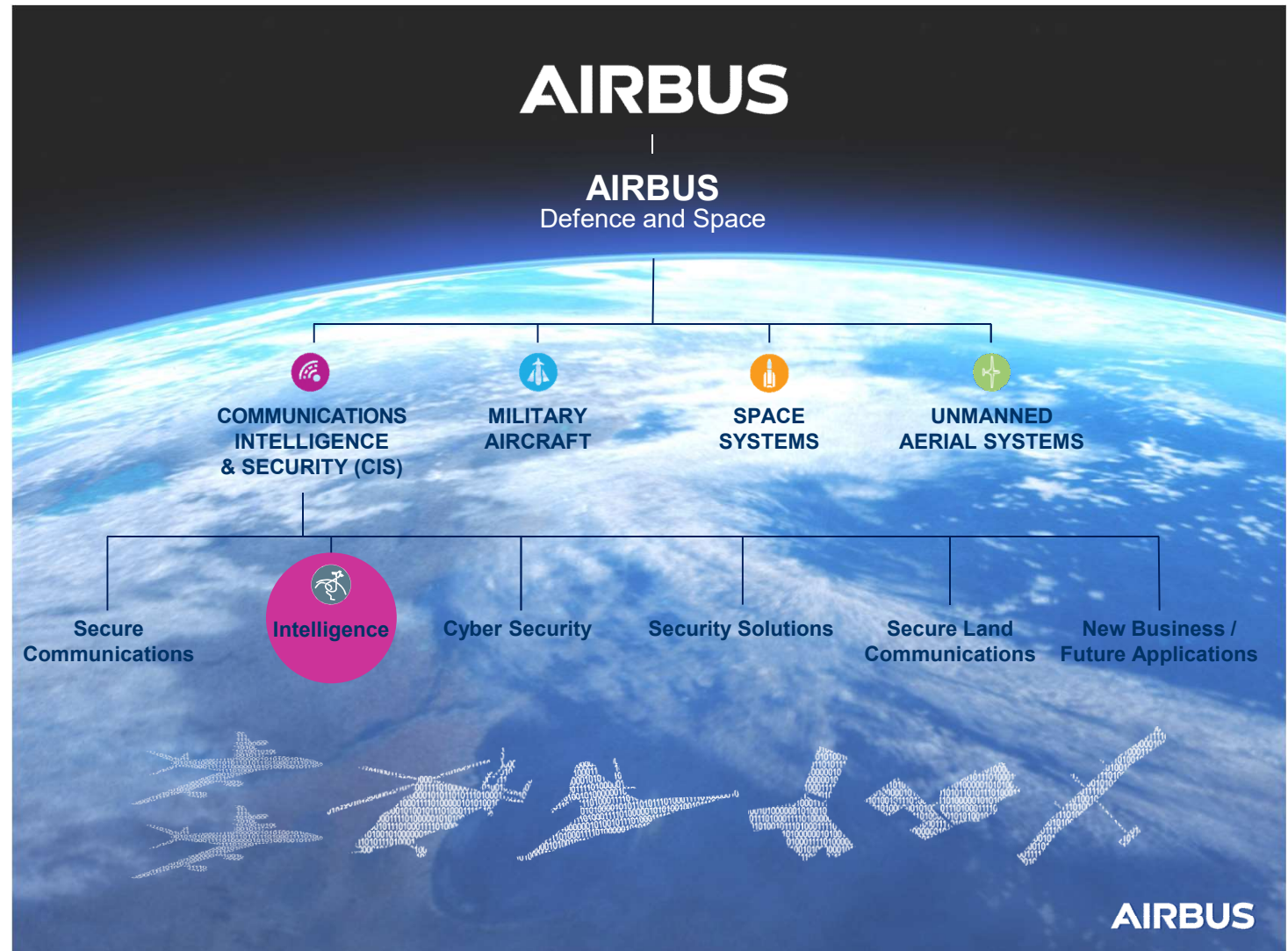
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# The Power of AIRBUS

World-Class Capabilities

Earth Observation

Defence Solutions



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# Delivering Value FROM DATA IN OUR Digitally CONNECTED World

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# Our Dedicated and Engaged Teams Worldwide Presence



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# Our Portfolio



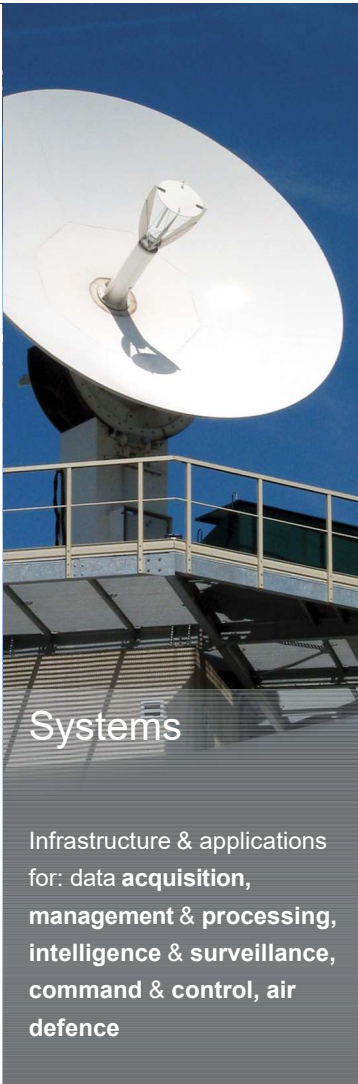
**Imagery**

Access to **imagery** and reference **layers** from the smartest **constellation**, combining **radar** and **optical** satellites




**Services**

Delivery of **application-specific** information resulting from the expert **analytical** processing of geospatial data



**Systems**

Infrastructure & applications for: data **acquisition**, **management & processing**, **intelligence & surveillance**, **command & control**, air defence



**Customer Support**

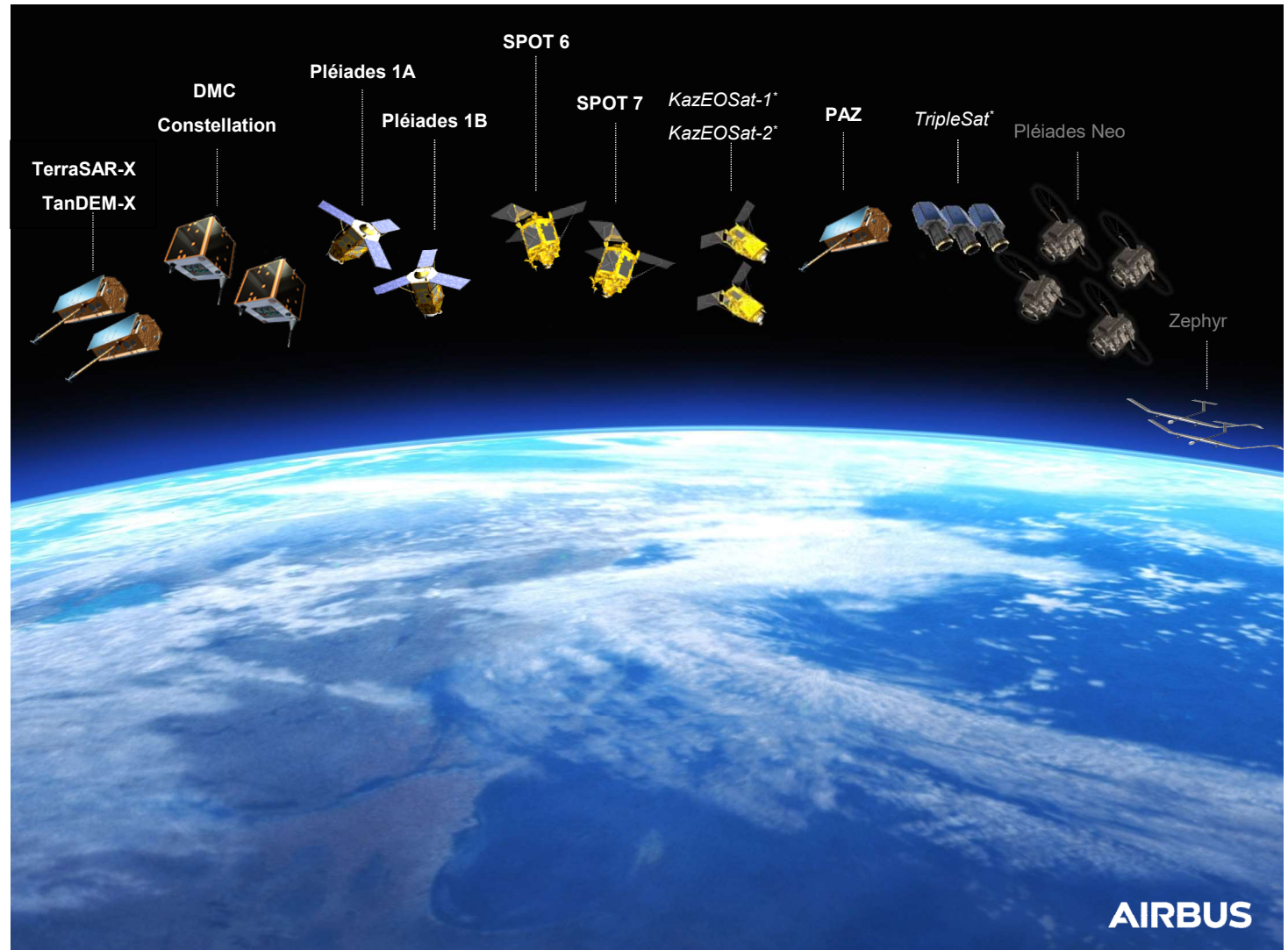
Technical, operational, marketing **assistance** and **training** for an efficient use of our products

**AIRBUS**

# Our Data Makes the Difference

**14**  
complementary  
satellites

\*including 5 partner  
sensors



# PAZ Satellit Launch

- 22.02.2018
- Built by Airbus
- TerraSAR-X / PAZ Constellation

**LAUNCH: PAZ**

STARTUP  
LIFTOFF  
MAX Q  
MAIN ENGINE CUTOFF  
PARACHUTE DEPLOY  
SECOND STAGE ENGINE CUTOFF  
PAYLOAD DEPLOY

**T-** 00:00:02

STAGE 2	TELEMETRY
SPEED	ALTITUDE
00000 km/h	00.2 km

**UPCOMING** **LIFTOFF**

**STARTUP**  
THE FALCON 9 FLIGHT COMPUTERS HAVE TAKEN CONTROL OF THE COUNTDOWN

**SPACEX**

- 30 minute orbit separation
- InSAR monitoring increased to weekly (4/7 day)
- True TerraSAR-X /PAZ constellation with identical orbit tube, imaging modes & interferometric capabilities

## TerraSAR-X / PAZ Constellation






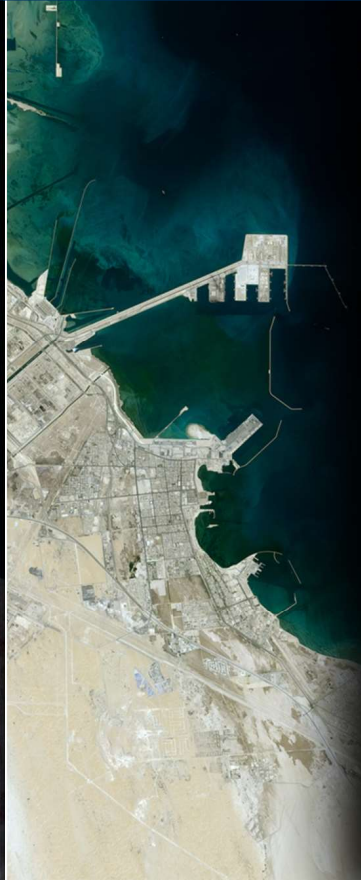

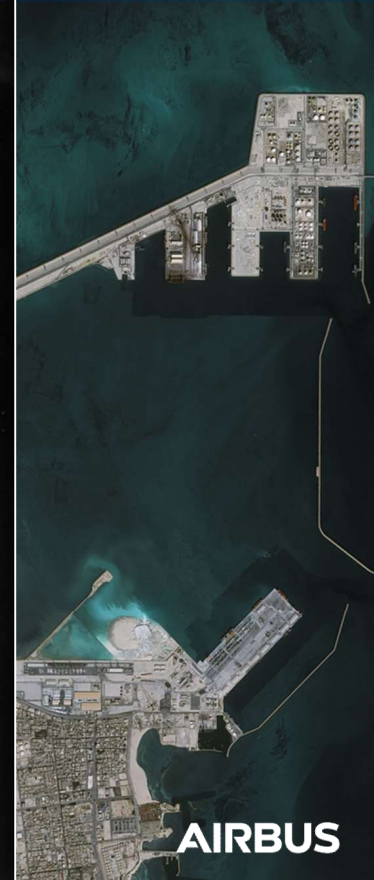
DEFENCE AND SPACE

# Our Data Makes the Difference

## Our Constellation

Diversity of Insights and  
Usage

Strong Positioning

<p>DMC Constellation 22m resolution</p>	<p>SPOT 6/7 1.5m resolution</p>	<p>TerraSAR-X/PAZ Constellation 0.25m-40m resolution</p>	<p>Pléiades 0.5m resolution</p>
			 <p><b>AIRBUS</b></p>

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# Delivering **Insight** for **Decision** **Making**



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# Delivering Insight for Decision Making

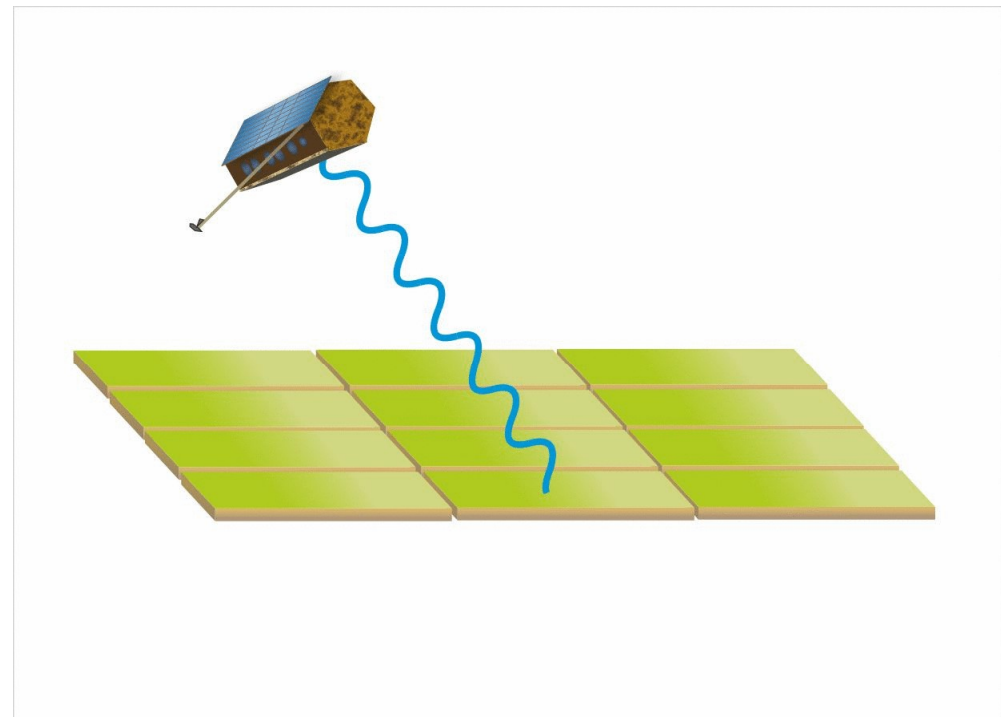
Multiple Markets

<p>01 Defence</p>  <p><b>BAE SYSTEMS</b></p> 	<p>02 Maritime Surveillance</p>  <p><b>CSTARS</b> <b>ConocoPhillips</b> <b>innovative navigation</b></p>
<p>03 Agriculture</p>  <p><b>CREDIT AGRICOLE ASSURANCES</b> <b>AXEREAAL</b> <b>JRC EUROPEAN COMMISSION</b> <b>FERRERO</b> <b>Nestlé</b></p>	<p>04 Forestry</p>  <p><b>afc</b> <b>Environment Agency</b> <b>ONF International</b> <b>Department for Environment Food &amp; Rural Affairs</b></p>
<p>05 Civil Institutions Security</p>  <p><b>Landgate</b> <b>ICC Institut Cartogràfic de Catalunya</b> <b>LLOYD'S LLOYD'S OF LONDON</b> <b>LFB LONDON FIRE BRIGADE</b></p>	<p>06 Oil, Gas, Mining</p>  <p><b>FUGRO</b> <b>bp</b> <b>TOTAL</b> <b>Shell</b></p>
<p>07 Avionics</p>  <p><b>NAVBLUE</b> AN AIRBUS COMPANY</p>	<p>08 Location-based Services</p>  <p><b>UBER</b> <b>Yandex</b> <b>Apple</b> <b>here</b> <b>TOMTOM</b> <b>Google</b> <b>AIRBUS</b></p>

# Surface Movement Monitoring (SMM) Basics

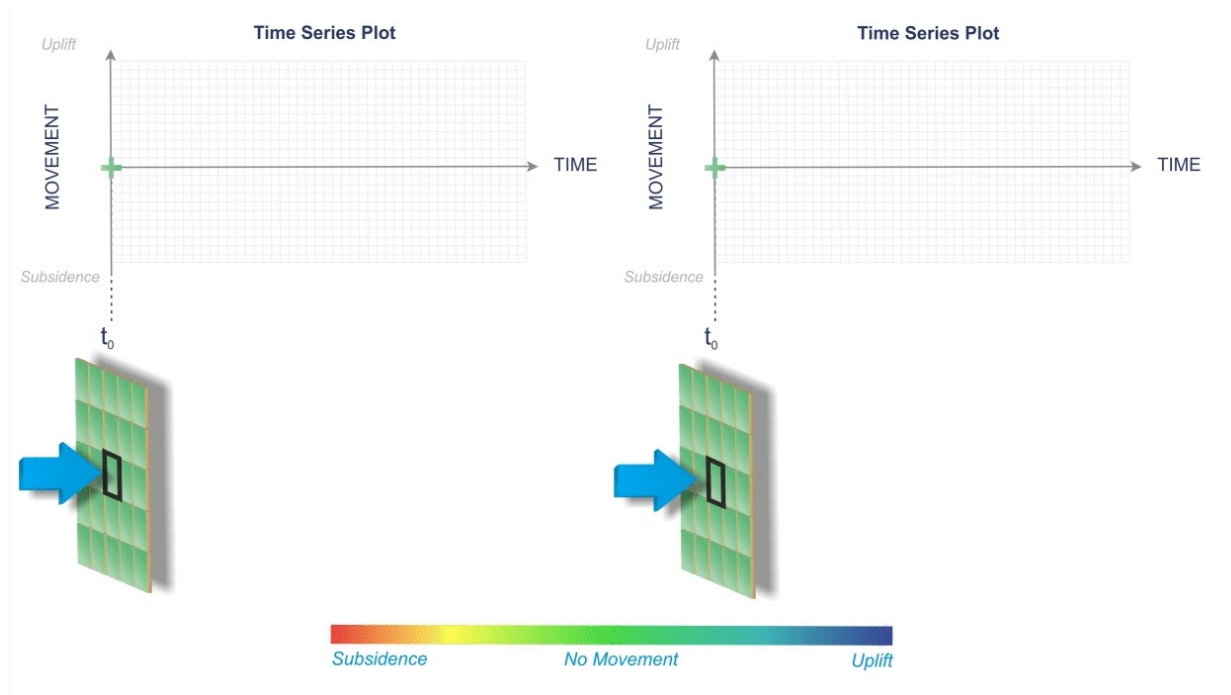
## Surface Movement Monitoring (SMM) Principle

- Comparing a pixel in a set of acquisitions at different times, the movement of the pixel within this period can be measured.
- The measurement direction is along the line-of-sight of the satellite sensor.
- Movements are indicated by a **path length difference**.



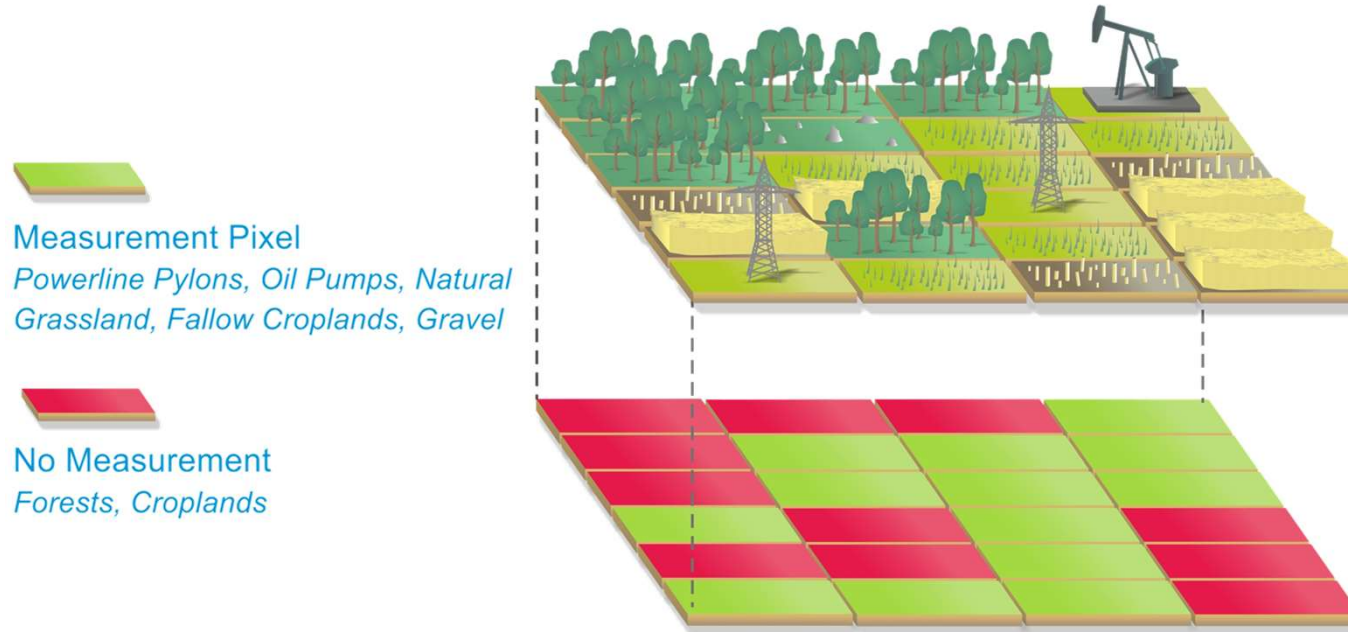
# Time Series of Surface Movement

- If more than two acquisitions are made, time series of movement can be evaluated



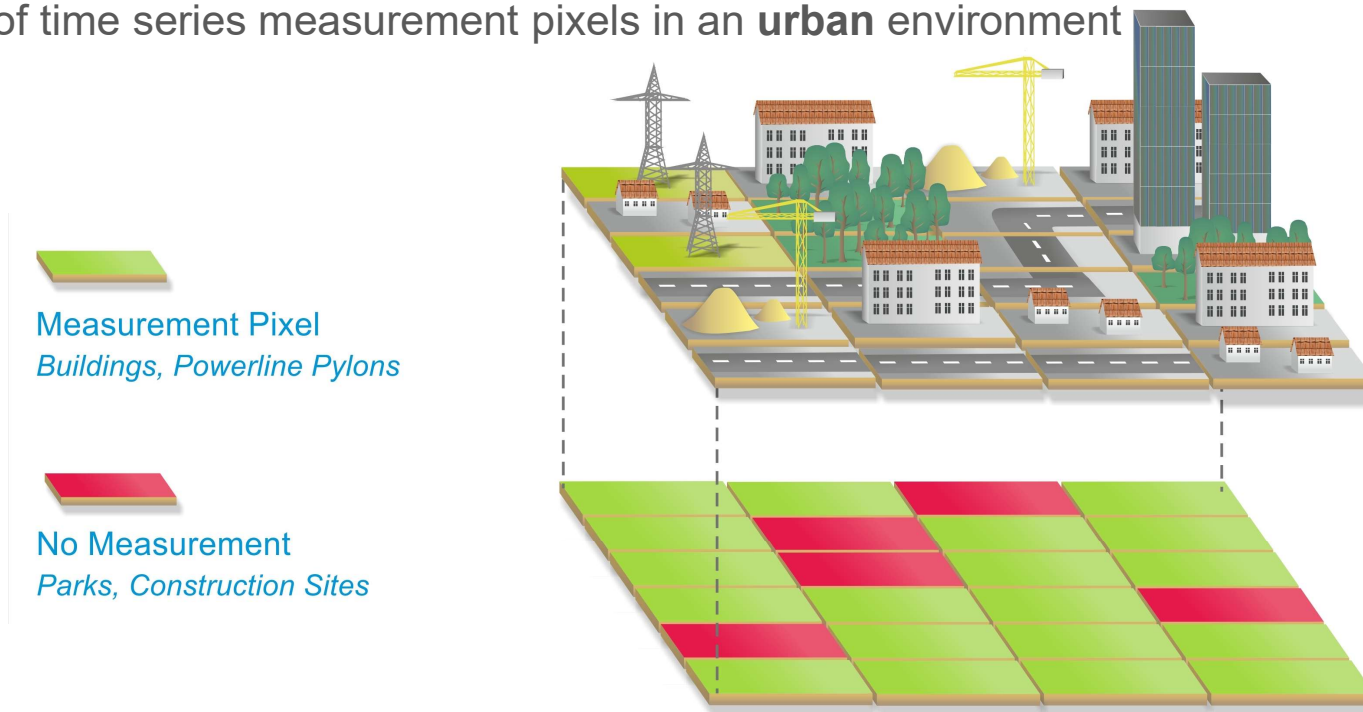
# Time Series of Surface Movement

- Example of time series measurement pixels in a **rural** environment



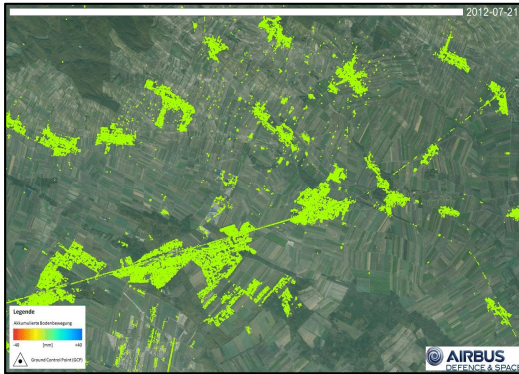
# Time Series of Surface Movement

- Example of time series measurement pixels in an **urban** environment

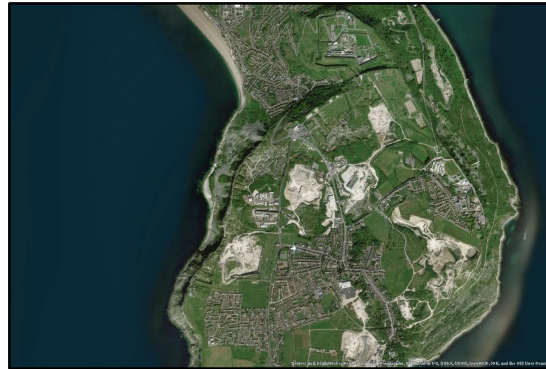




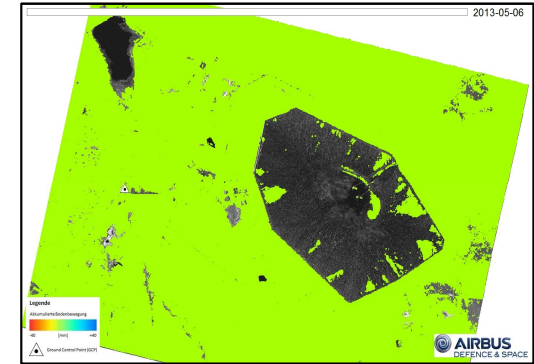
### Oil & Gas: Austria



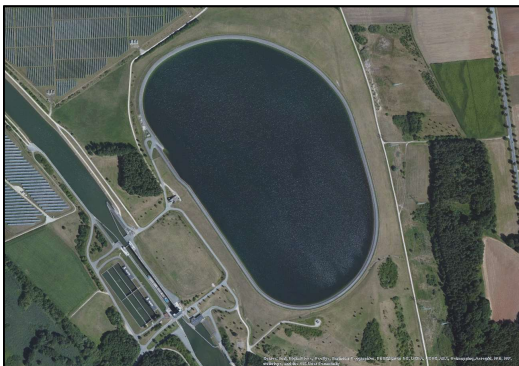
### Landside: United Kingdom



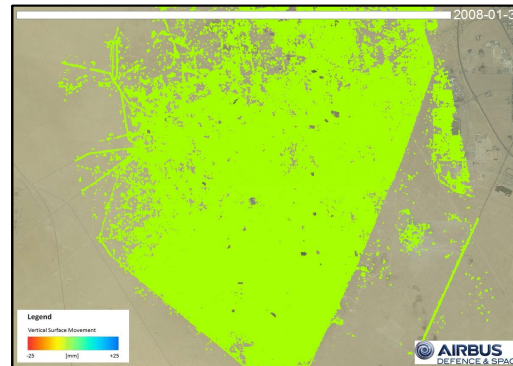
### Mining: South Africa



### Civil Engineering: Germany



### Oil & Gas: Kuwait

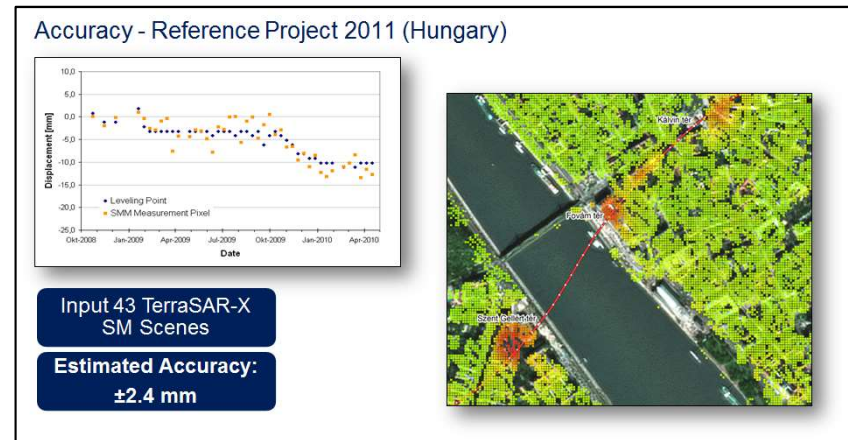
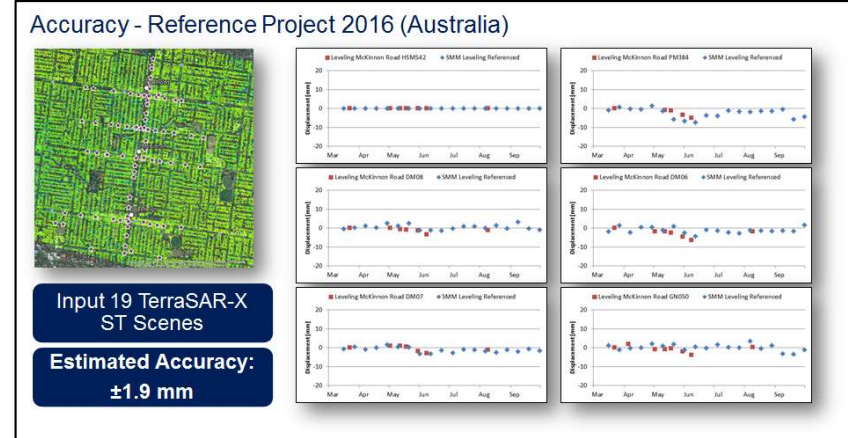
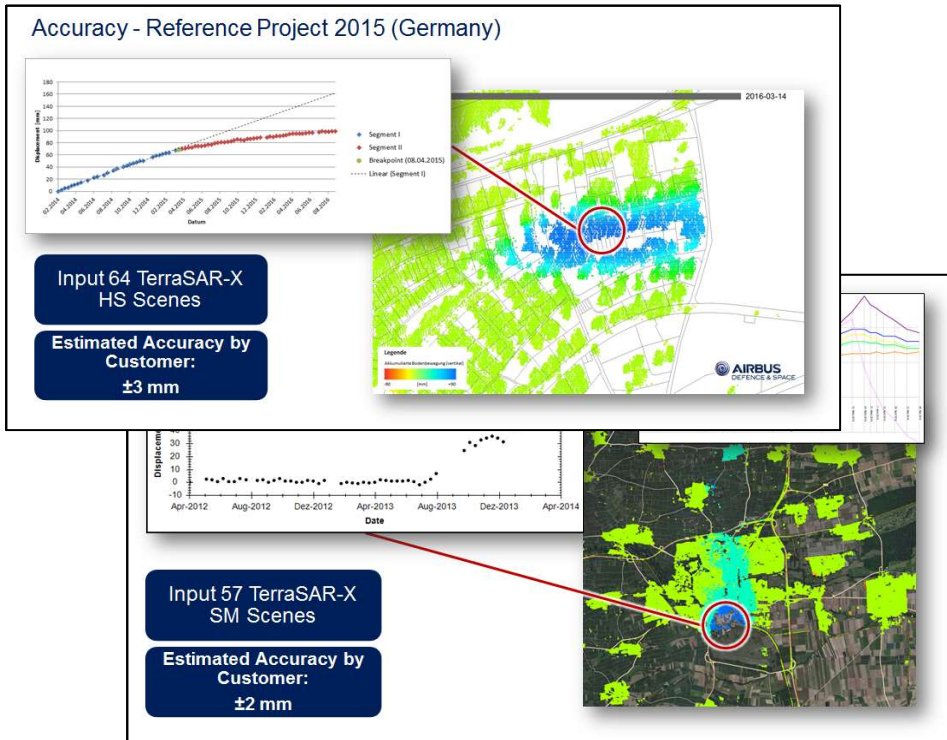


### Civil Engineering: Germany



# SMM - Accuracy

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## SMM – Accuracy (TerraSAR-X)

Common to GPS, SMM is a relative measurement with respect to a reference point

Precision depends on: number of images, pixel density, atmosphere, reference point, etc.

	Velocity	Displacement
Precision	~1 mm/yr	<3 mm

# Surface Movement Monitoring – Web Platform: GeoView

# SMM - GeoView

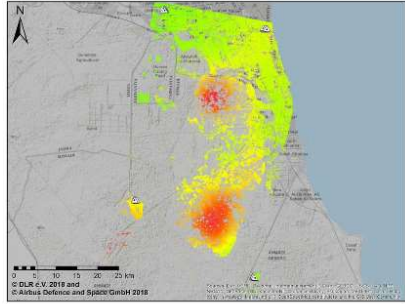
- SMM web platform (online APP)
- Visualization and analytic tools (time series)
- User dedicated access from anywhere in the world (browser based)
- Secure client portal

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Surface Movement Monitoring AIRBUS

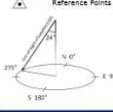
**Satellite Based Surface Movement Monitoring – FACT SHEET**  
Burgan Oil Field (Kuwait)



**Legend**

Vertical Movement Velocity  
-10 [mm/yr]    10

Reference Points



**Area of Interest**

<b>Burgan Oil Field</b>
<b>Country</b>
<b>Kuwait</b>
<b>Area</b>
<b>1850 km<sup>2</sup></b>

**Input Data**

<b>Sensor</b>	TerraSAR-X
<b>Mode</b>	StripMap
<b>Resolution</b>	~3 m x 3 m
<b>Count</b>	81 scenes
<b>Time Span</b>	07/02/2014 – 26/11/2016

**Processing**

<b>Software</b>	SARscape v5.4	<b>Method</b>	SBAS
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**Result**

Specifications		Attribute Description	
<b>File Format</b>	ESRI File-Geodatabase (GDB)	<b>Velocity</b>	Average movement velocity [mm/yr]
		<b>V_Precisio</b>	Precision of movement velocity [mm/yr]
<b>Pixel Spacing</b>	X (East): 10 m Y (North): 10 m	<b>Deviation</b>	Standard deviation of movements (with respect to average velocity) [mm]
<b>Projection (Datum)</b>	UTM Zone 38N (WGS 1984)	<b>X, Y</b>	Geogr. location of measurement pixel [m]
<b>Output Movement Direction</b>	Vertical	<b>LOS_In</b>	Line-of-sight incidence angle [°]
		<b>D_YYYYMMDD</b>	Movement at date YYYYMMDD [mm]

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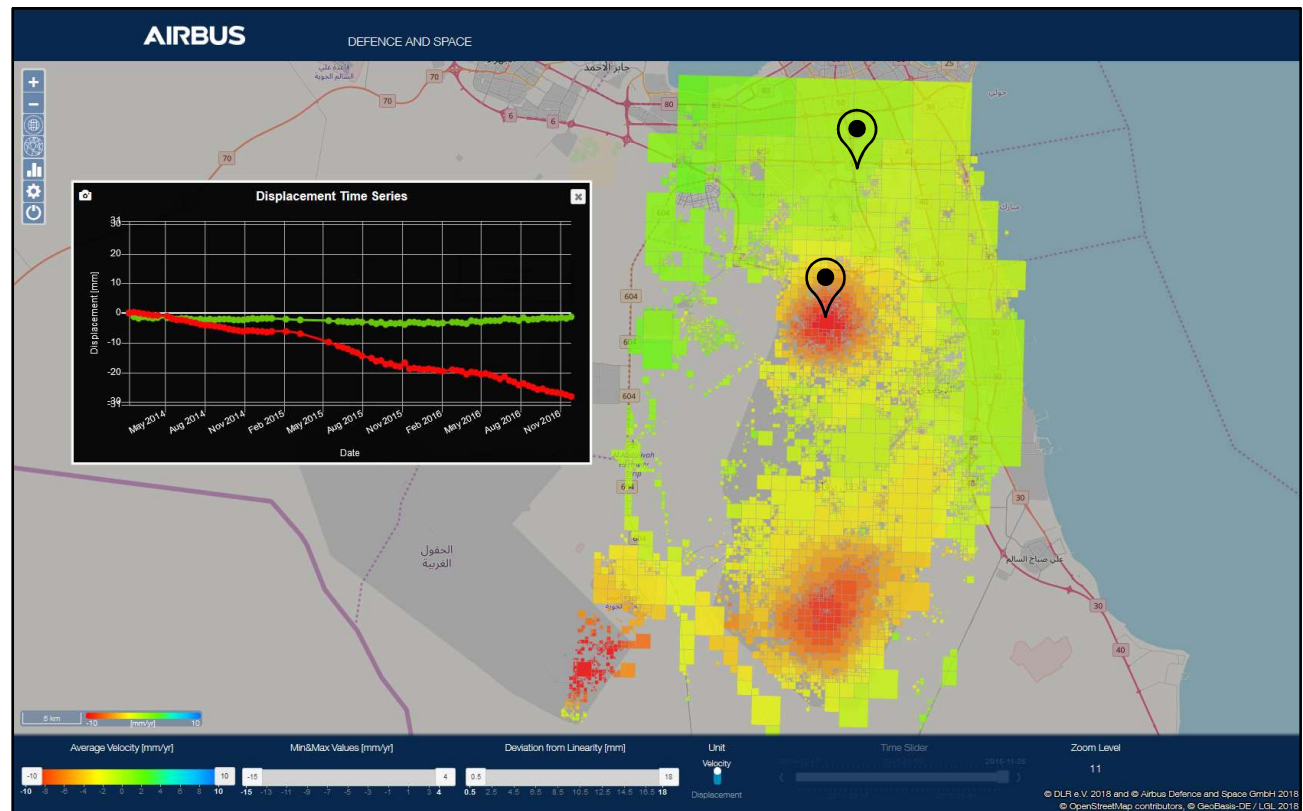
Logout

Tengiz Oil Field (Kazakhstan)  
2016-2017  
[Download Fact Sheet](#)

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# SMM - GeoView

- SMM web platform (online APP)
- Visualization and analytic tools (time series)
- User dedicated access from anywhere in the world (browser based)
- Secure client portal



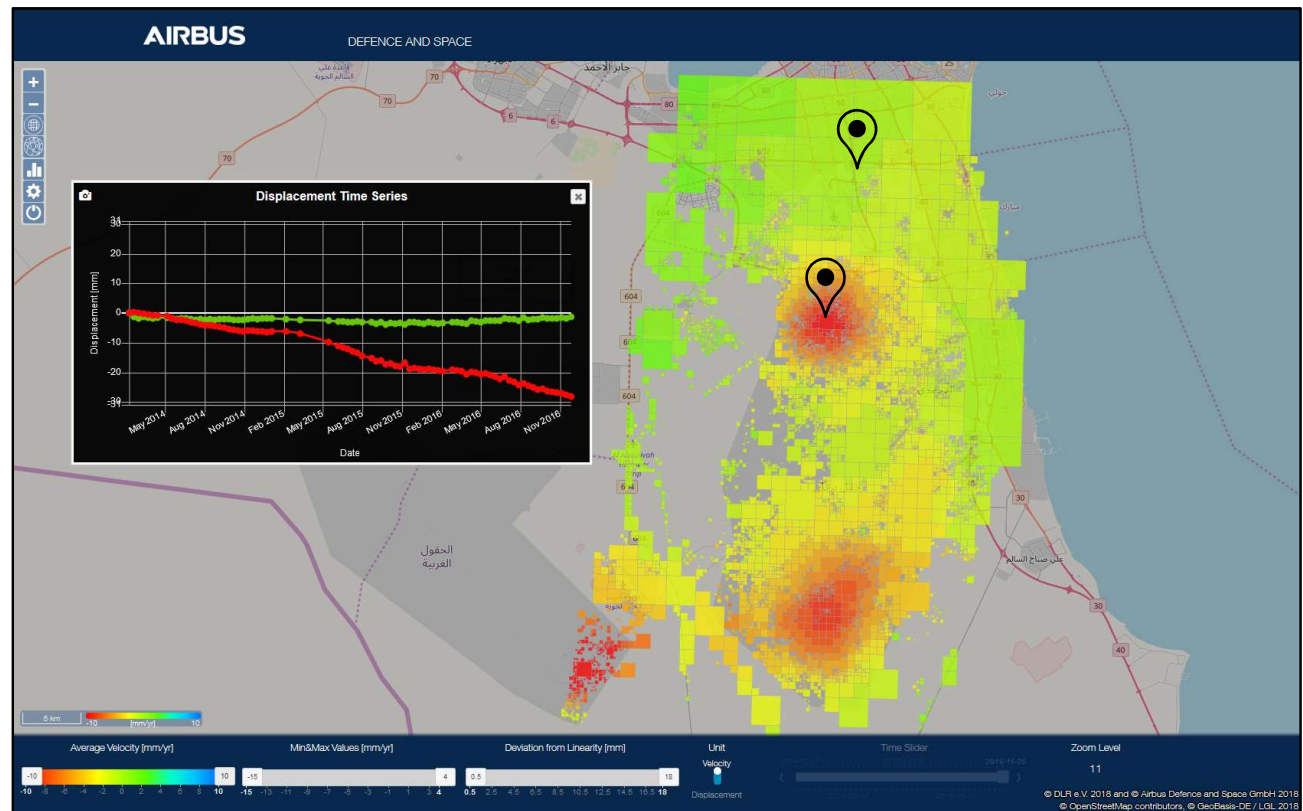
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# Surface Movement Monitoring – Burgan Oilfield, Kuwait

# Burgan Oilfield, Kuwait

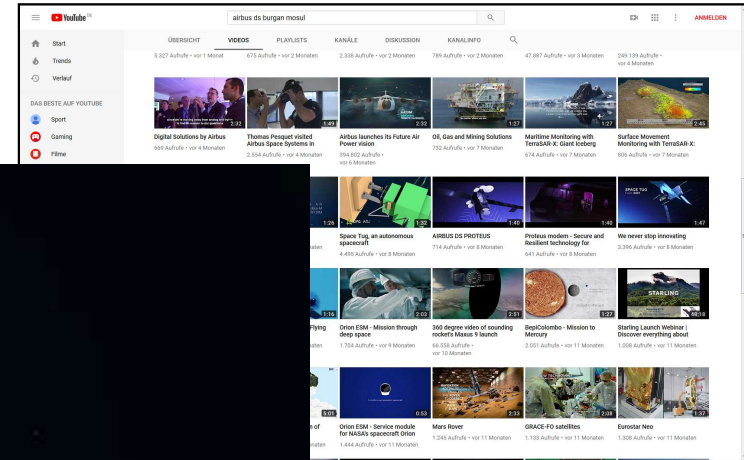
- Monitoring period ~2.5 year
- 81 TerraSAR-X SM Scenes
- Resolution ca. 10 m x 10 m

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# Burgan Oilfield, Kuwait



Airbus DS' YouTube Channel

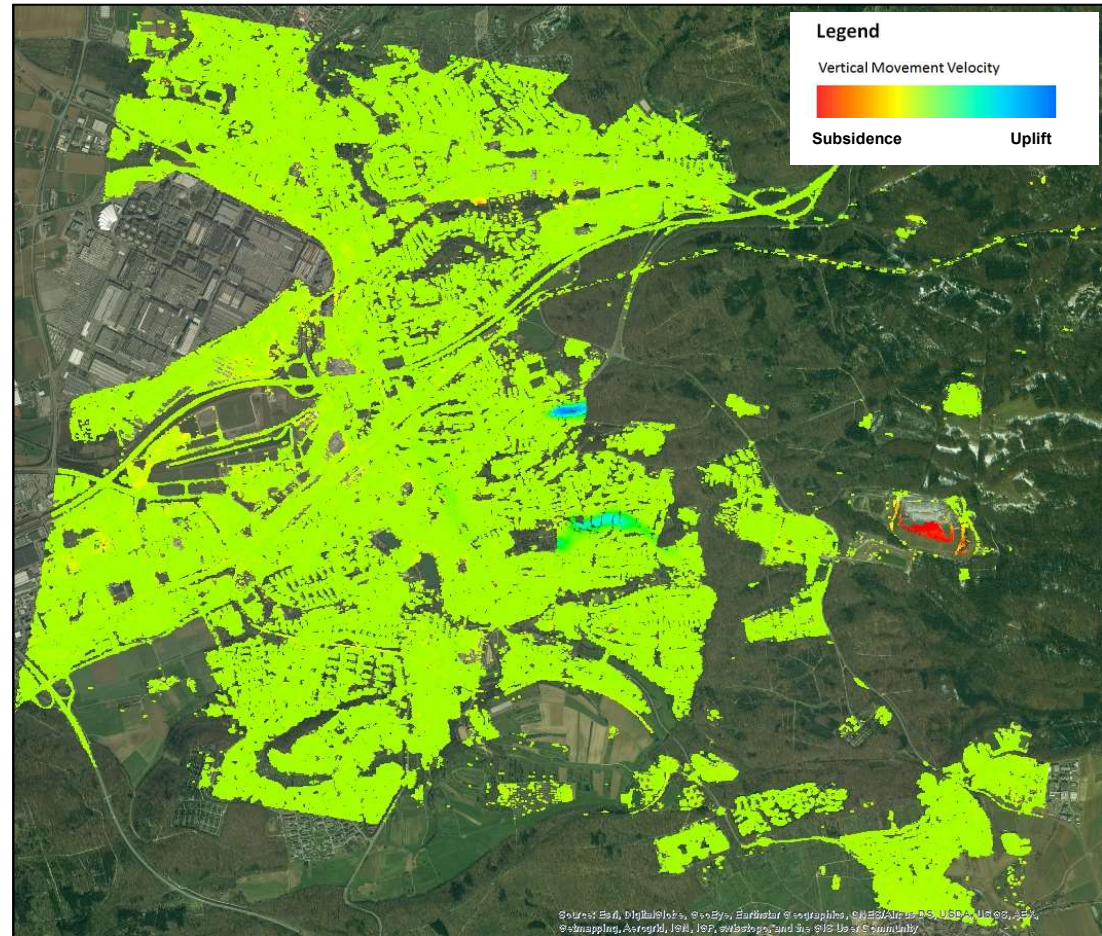


# From Millions of Pixels to Actionable Information (Value Adding)

# Satellite Measurement

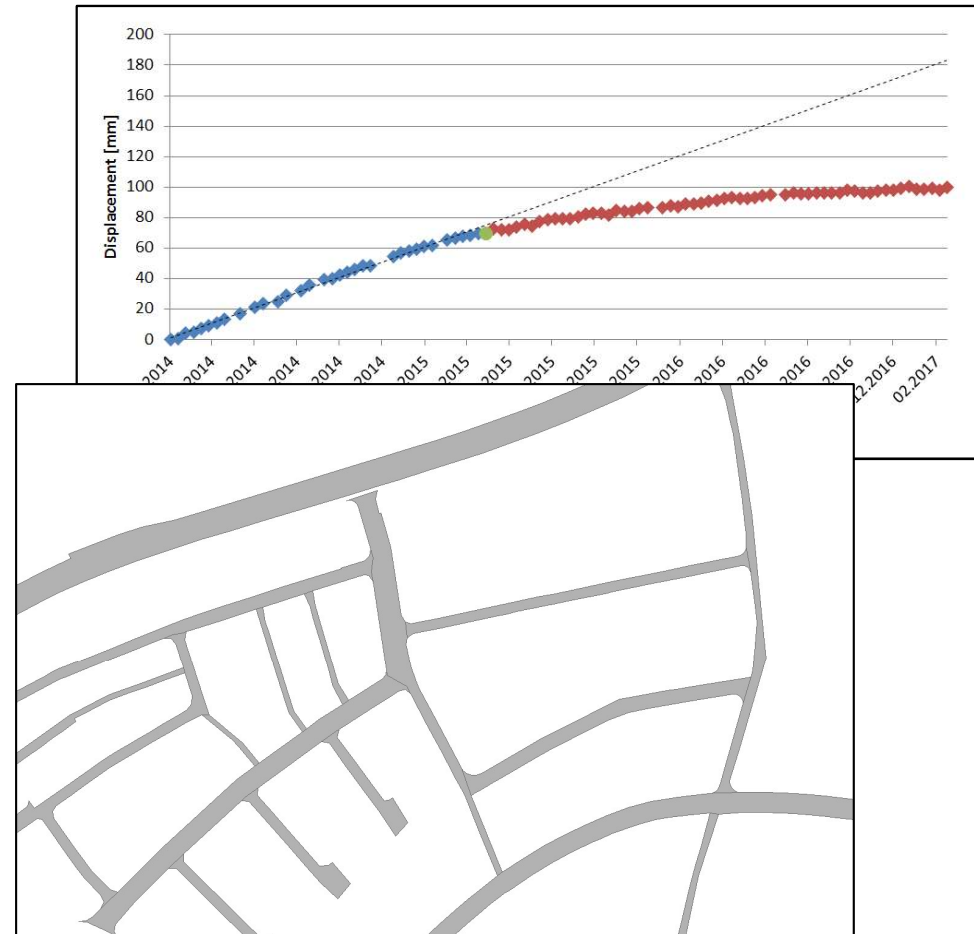
- **124** TerraSAR-X HS scenes
- Resolution **2 m x 2 m**
- Monitoring period **>4 years**
- **2,5 Million** measurement pixels
- Ongoing updates (quarter year)

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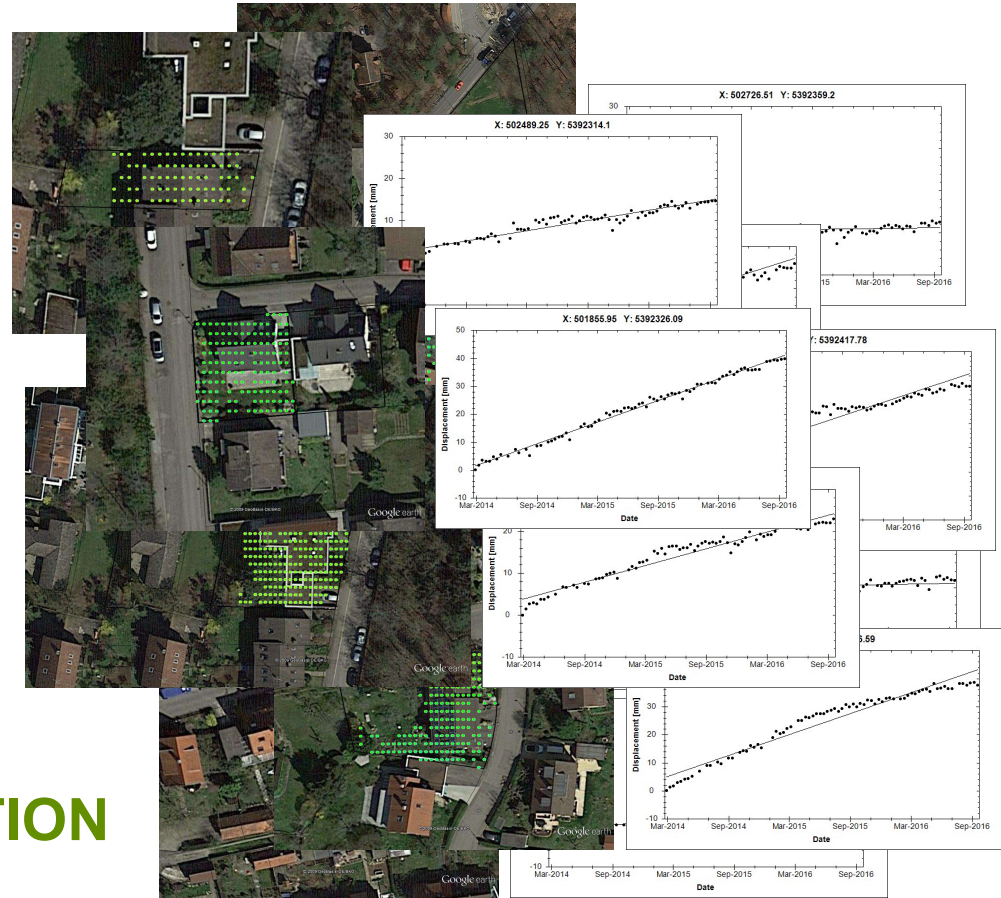
# Satellite Measurement

- Monitoring of uplift zones within the city
- Assessment of consequences in the course of geothermal well reconstruction
- Derivation of spatio-temporal causalities
- Regulation of damages and perception of citizens' interests



# Challenge (Big Data)

- Available:
  - Million of Measurement Pixels
  - Difficult to handle **DATA** mass
- Necessary Resources:
  - Terrabyte large storage volume
  - GIS Software (local)
- Required:
  - convenient, actionable **INFORMATION**



## Solution (Data Mining)

- **Mass Reduction**
  - Clustering
  - Generalization
- **Linking** to other complementary geospatial information
  - Allocation to railways, houses, roads
- **Value Adding**
  - Convenient, actionable information for decision makers
- **Online Visualization**



## SMM Result

- Monitoring period **1 Year**
- **34** TerraSAR-X SM Scenes
- Resolution ca. **3 m x 3 m**
- Millions of Pixels

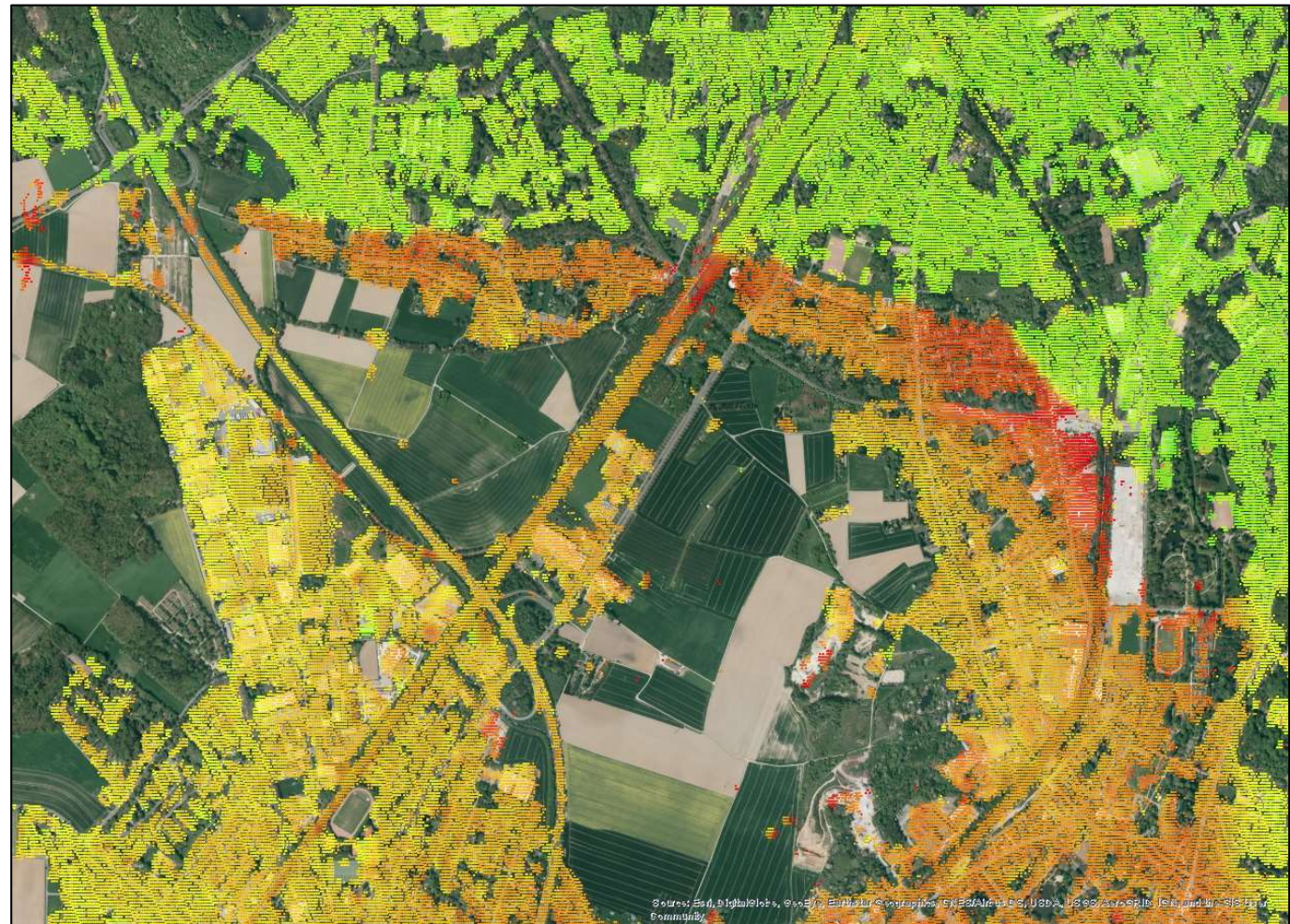
### Legend

Vertical Movement Velocity



Subsidence

Uplift



# Clustering

- Advanced Quadtree clustering
- Mass reduction for performant online visualization (GeoView)
- Time series analyzable

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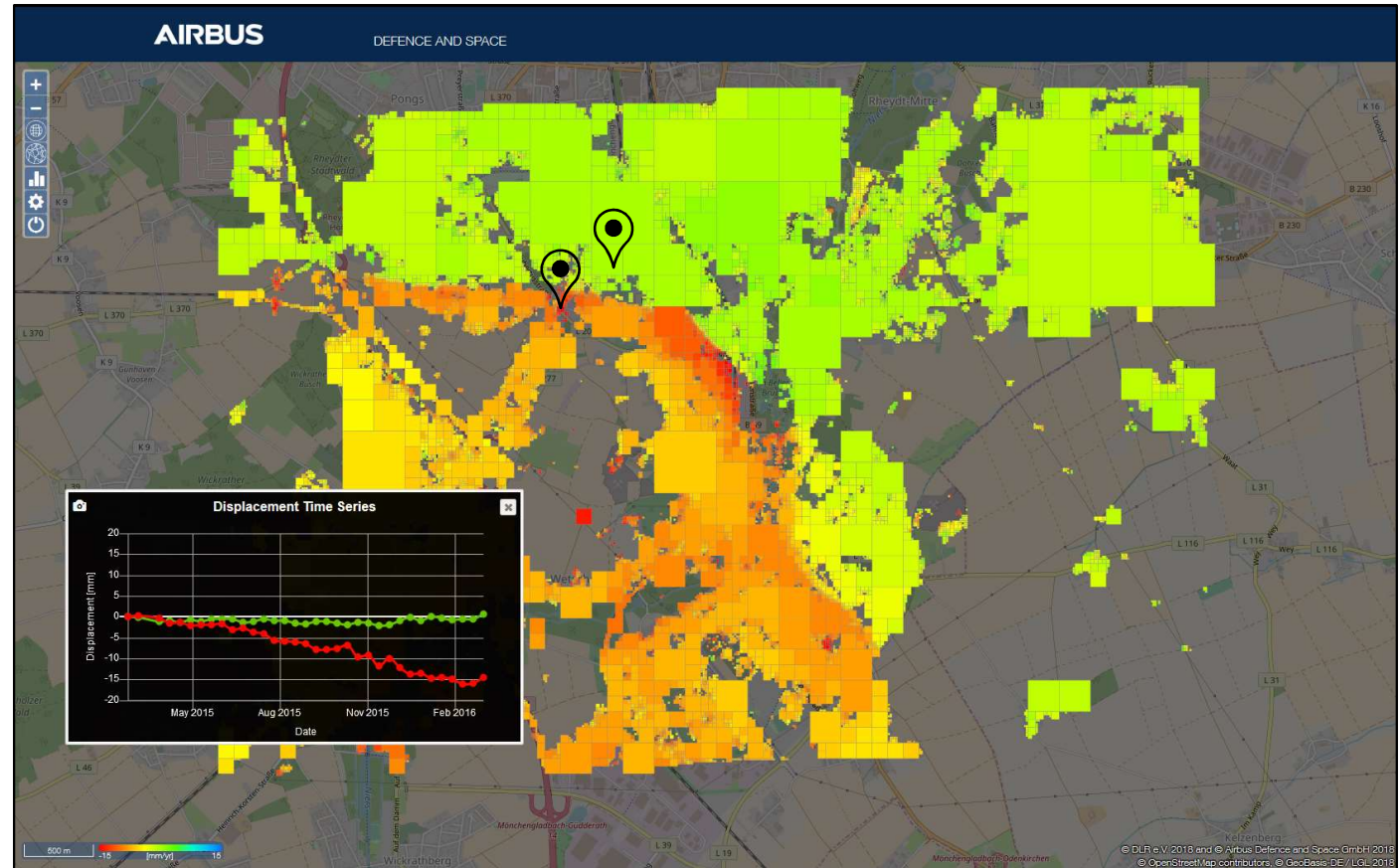
**Legend**

Vertical Movement Velocity



**Subsidence**

**Uplift**

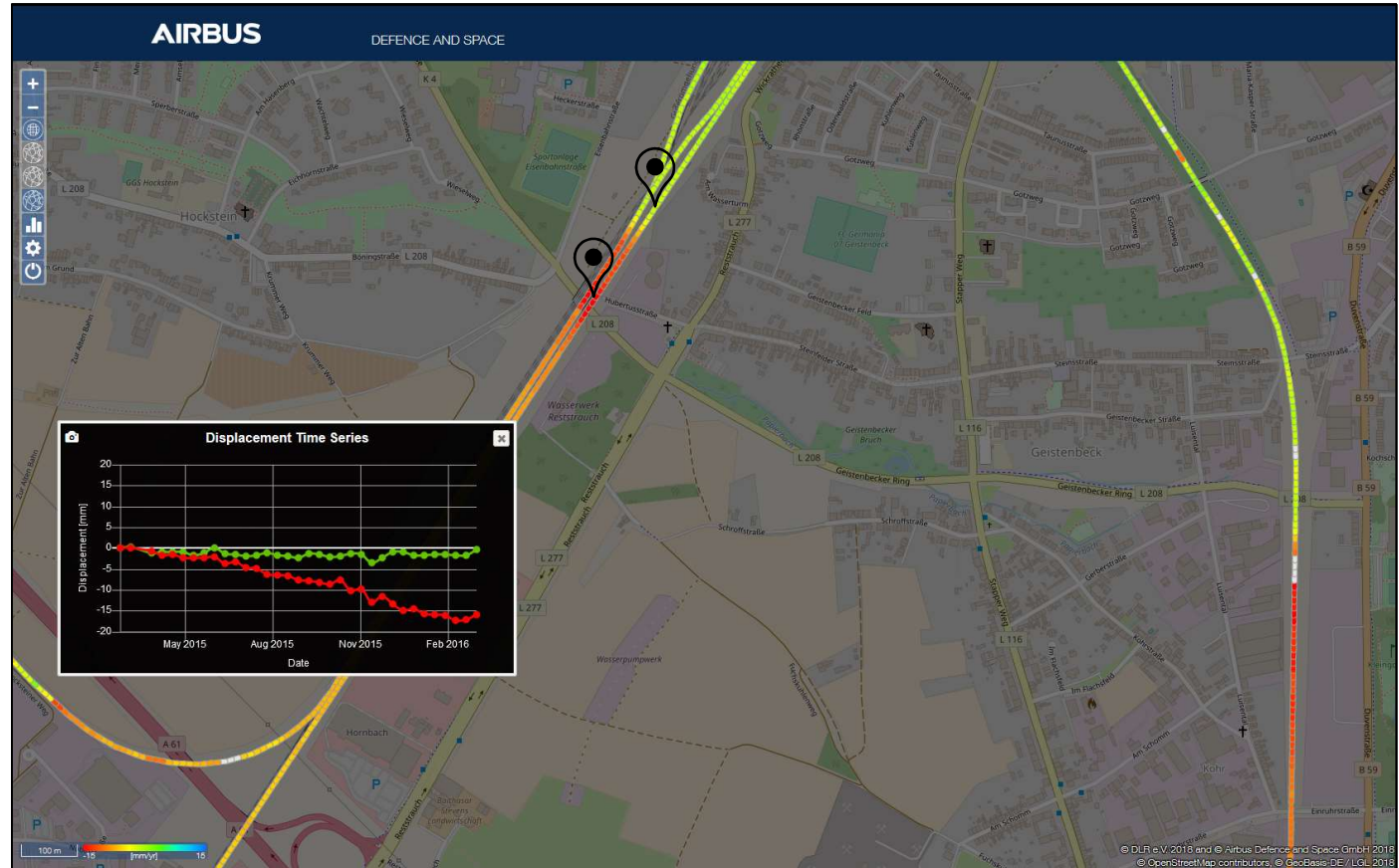




# Allocation

- Point allocation to railways
- Reduction and linkage
- Time series analyzable

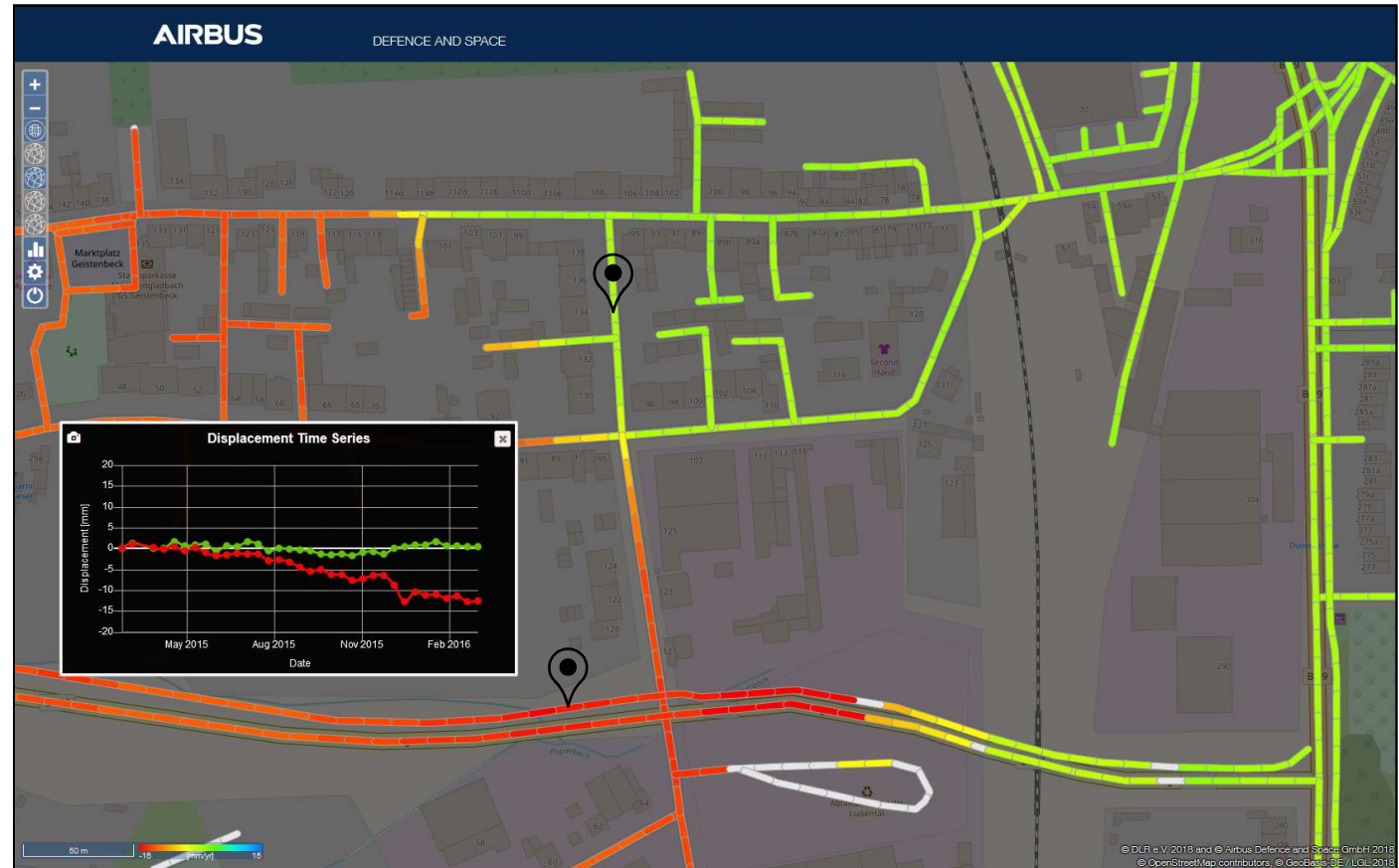
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# Allocation

- Point allocation to roads/streets
- Reduction and linkage
- Time series analyzable

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# Allocation

- Point allocation to **houses**
- Reduction and linkage
- Time series analyzable

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### Legend

Vertical Movement Velocity



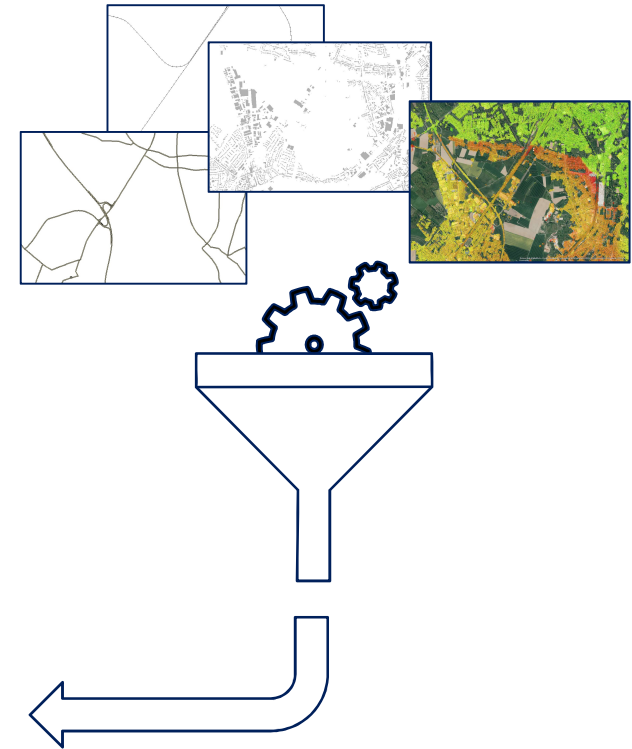
Subsidence

Uplift



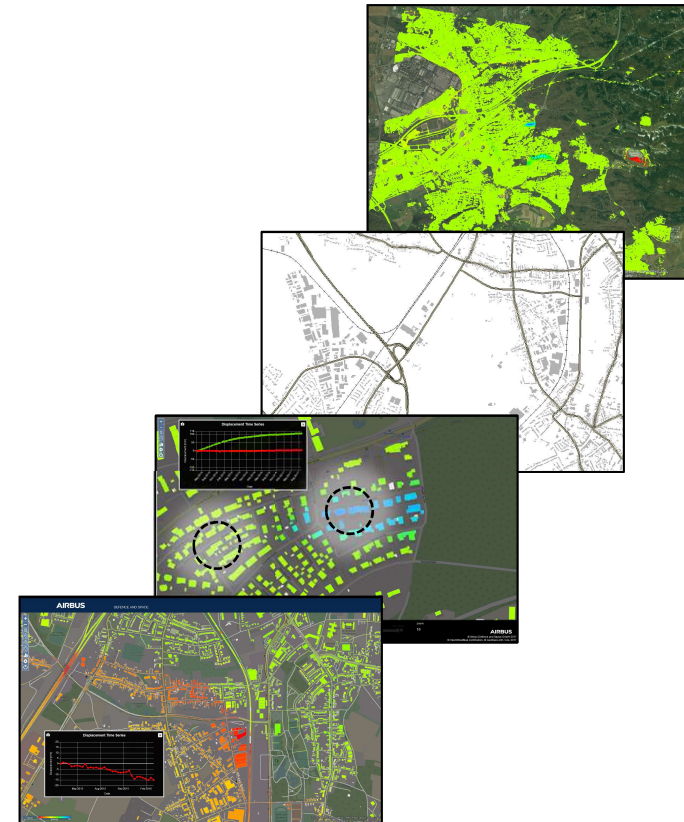
# Value Adding

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# Conclusion

- **Very high resolution** TerraSAR-X data allow reliable spatio-temporal **surface movements** estimation
- **Millimeter Accuracy** can be derived under optimal conditions
- Monitoring of **individual buildings** possible
- **Linking** to other geo-data yield convenient and **actionable information** (value adding)
- Easy to use **online visualization** (GeoView)



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