VOLUME 23 | JULY 2020

SPOTLIGHT

Minimizing the impact of desert locust swarms in East Africa

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LOCUSTS SWARM EAST AFRICA, COMPOUND FOOD INSECURITY

East Africa is currently experiencing one of its largest-ever recorded locust invasions. In early 2020, the UN's Food and Agriculture Organization (FAO) helped facilitate a crisis response in partnership with 10 different countries. As of May, an estimated 720,000 tons of cereal had been saved.

Over the past couple years, abnormal weather, violent conflict and insufficient resources for preventative pest control have impeded swarm reduction efforts throughout the region and compounded pre-existing food shortages. In 2018 and 2019, the North Indian Ocean experienced its two most active cyclone seasons on record. The significant rain and abnormal levels of vegetation growth created ideal locust breeding conditions across East Africa, the Gulf States and parts of South Asia. By the end of 2019, major locust swarms had emerged in East Africa. By December 2019, over 175,000 acres of farmland in Ethiopia and Somalia were destroyed by locusts. In Somalia, food shortages caused by locust damage were so severe that residents in agrarian areas began cooking and consuming the locusts.

Researchers are significantly concerned that prolonged locust breeding conditions and limited mobility and supply shortages cause by COVID-19 may set off another wave from the second generation, causing far more devastation and widespread food insecurity as many farmers prepare to harvest crops in June.

This issue of Maxar Spotlight utilizes remote sensing techniques and geospatial modeling to analyze the areas in Ethiopia, Kenya and Somalia that are currently vulnerable to locust swarm damage. The Spotlight also highlights vulnerability in South Sudan in the event of future migration. By analyzing the spatial relationship among key environmental, geopolitical and socioeconomic conditions, Maxar's unique tools and methodology can be used to precisely target locust breeding hot spots, improve the supply management and application of pesticides and reduce the impact on food security.

SUMMARY OF UNIQUE TOOLS & APPLICATIONS

Human Landscape. Maxar Human Landscape is a foundational human geography dataset that provides rich attribution and metadata at a countrywide scale. Each dataset comprises 60+ individual data layers across thirteen standard human geography themes. By leveraging high-resolution satellite imagery to significantly enrich thousands of publicly available and conflated data sources into up-to-date and analysis-ready foundational data, Human Landscape reduces operating costs and accelerates time-to-mission for complex geospatial analysis or taskings. For this assessment, Human Landscape was used to provide locations with sandy soil, one soil characteristic preferred by desert locusts for breeding.

Global Weather Interactive (GWI) and WeatherDesk. An application within Weather Desk™, GWI is the industry's leading archive of global historical weather information. GWI provides custom access to over 900 domestic and 10,000 international weather stations for analysis of temperature extrema, precipitation and derived parameters like average temperature, average precipitation and normal departures for each. For this assessment, GWI was used to identify locations with higher soil moisture, as desert locusts prefer to lay eggs in soil that has moisture extending between 5 and 10 centimeters below the surface.

BaseVue LULC. Maxar BaseVue is a standard global land use/land cover (LULC) dataset. Derived from Landsat imagery, BaseVue applies multi-temporal, semi-automated classification to map LULC at a resolution of 30 meters—a cost-effective solution fit for large-scale environmental applications. For this assessment, BaseVue was used to identify agricultural areas, which are extremely important for the region's food security and more likely to attract locusts than uncultivated vegetation.

WHAT IS THE DESERT LOCUST?

Desert locusts are among the world's most destructive pests. While locusts can live solitary lives, during any phase of their development, they can turn gregarious and exhibit swarm behavior. The transformation in locust behavior is a complex interaction of environmental and hormonal factors. Desert locusts have a life cycle of about three to five months and live in the dry and arid regions from Mauritania all the way to India. They usually only breed in the rainy season, because the female locust must lay its eggs in damp soil. But when conditions are ideal for breeding, there is an exponential increase in the population—roughly twenty fold every three months, according to Keith Cressman, a senior locust officer at the UN's Food and Agriculture Organization (FAO). Because of this, the potential for locust swarms is greatest following significant or uncharacteristic rain and new vegetation growth.

The behavior of the typically solitary locust changes when an area becomes over-populated or when they start congregating in areas where vegetation remains. This convergence prompts the locusts to release serotonin, which increases their social behavior, endurance, movement and even the variety of vegetation they consume. When locusts enter the gregarious phase, they swarm from food source to food source.

Full-grown gregarious locust swarms are capable of traveling over 80 miles in a single day and can cover over 460 square miles. Swarms can also contain anywhere from 40 to 80 million locusts in half a square mile. Each locust is capable of consuming its own weight in plant matter per day, which is roughly 2 grams. To put that in perspective, a swarm the size of Paris is capable of consuming the same amount of food as half of France's total population, according to FAO.

THE AMOUNT OF PLANT MATTER A GIANT LOCUST SWARM IS CAPABLE OF EATING EACH DAY

MILLION LBS

423

GREGARIOUS PHENOTYPE LOCUSTS
(TONY KARUMBA / GETTY IMAGES)

PREVENTION LIMITATIONS

Several factors impact government and commercial programs designed to control locust swarms in their territory. Some countries in East Africa lack adequate financial resources as well as equipment for large-scale pest control operations. Locust swarm locations are often remote and difficult to access for a variety of reasons, including lack of transportation infrastructure, flooding or violent regional conflict. Anticipating the movement of locusts is also challenging, as they are capable of traveling over 80 miles per day depending on regional wind conditions.

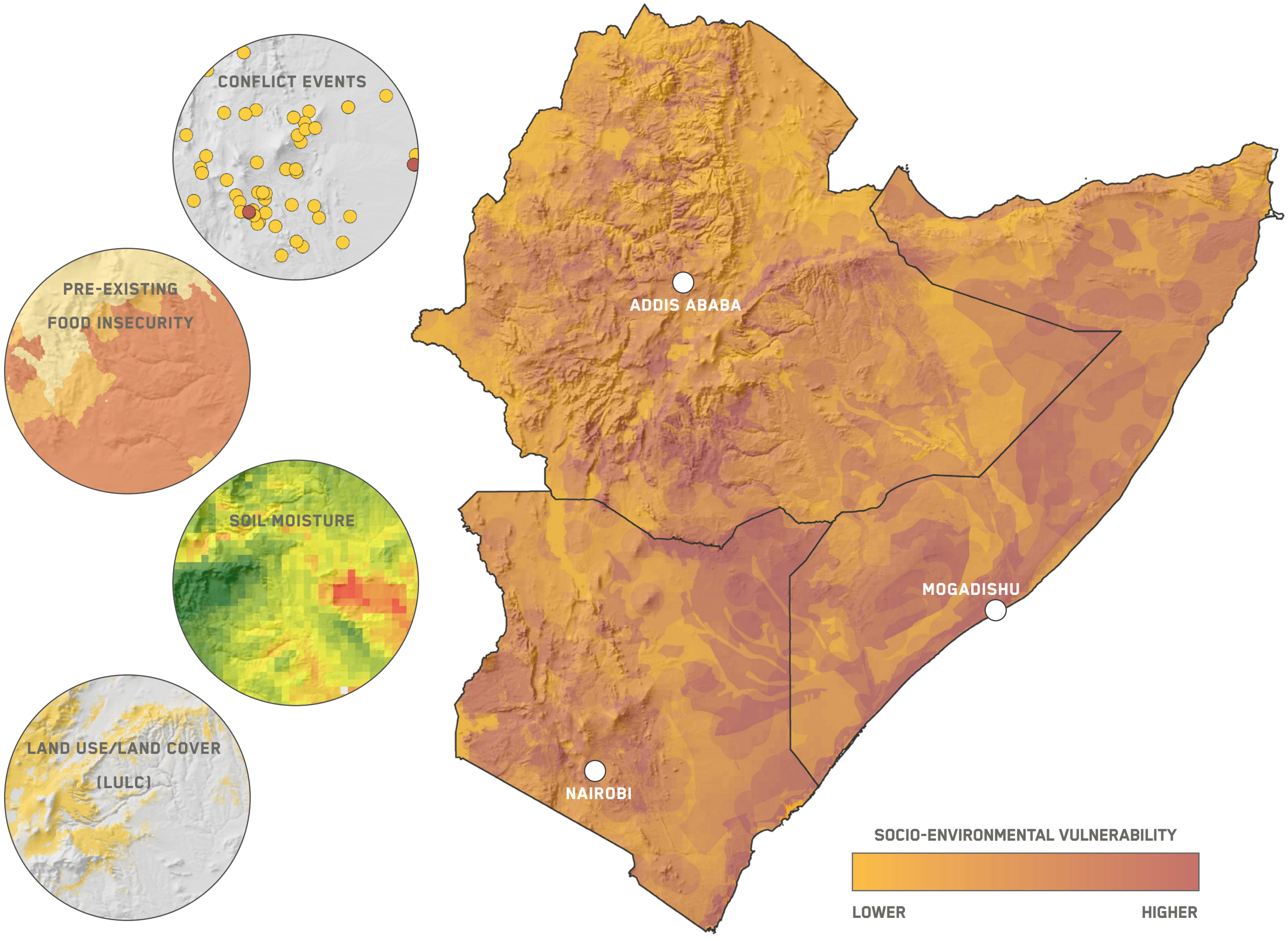
Additionally, COVID-19 related shortages and mobility restrictions have hindered several countries' pesticide application programs. Although the FAO's crisis response in early 2020 received widespread support and more than $130 million in generous funding, locust control equipment and pesticides did not arrive in the region until mid-March. At this point, the second generation of locusts had started hatching. Locusts are most vulnerable to pesticide application during the first two weeks of their life cycle, as they are unable to fly during this period.

MODELING VULNERABILITY TO LOCUST SWARMS

By utilizing remote sensing technology and geographic information system (GIS) workflows, Maxar helps to offset some of the aforementioned challenges by illuminating locations that are at greatest risk for locust invasions and swarm damage. This allows for improved pest control planning and supply management. The following vulnerability model aggregates several complex raster layers that are based on key environmental and social conditions that impact both locust activity and mitigation measures. The individual layers include violent conflict, pre-existing food insecurity, soil characteristics (soil type and soil moisture) and land use/land cover. The next several pages provides further information about each individual layer.

DESERT LOCUSTS FEED ON A FARMER'S CROPS IN KENYA ON JANUARY 24, 2020 (BEN CURTIS / AP PHOTO)

SOCIO-ENVIRONMENTAL VULNERABILITY MODEL



CONFLICT AND FOOD INSECURITY

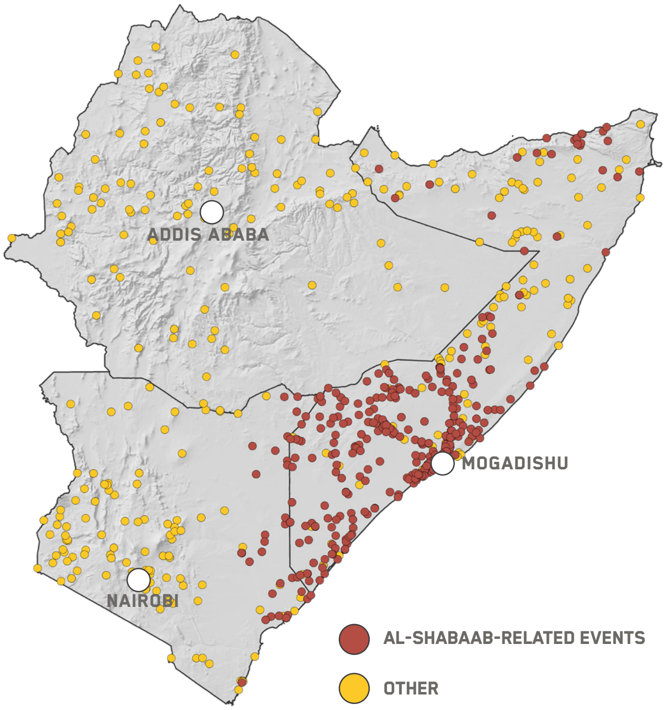
Violent conflict is a significant impediment to pest control efforts by governments and international aid organizations. In Somalia, locust eradication efforts are hindered by the violent extremist organization al-Shabaab, which operates throughout central and southern Somalia. Very little, if any pesticide applications can be made in areas controlled by the group because of its weapons and lethality. Violent attacks by the group compromise the safety of both ground and aerial locust spraying operations.

In Ethiopia and Kenya, the majority of conflict is the result of ethnic violence, as well as clashes between ethnic militias and government forces. Recent events in western Kenya have also included violence between police and civilians, although much of this could be attributed to COVID-19 curfews and restrictions. While these attacks in Ethiopia and Kenya are not as severe or widespread as the violence reported in Somalia, sporadic conflict could hinder mobility and compromise the safety of personnel and organizations working to mitigate the locust threat. The map on the bottom left depicts the location of violent conflict events from January 2019 to May 2020. This was added to the aggregate vulnerability model as a kernel density layer which quantifies the distribution and clustering of violent conflict.

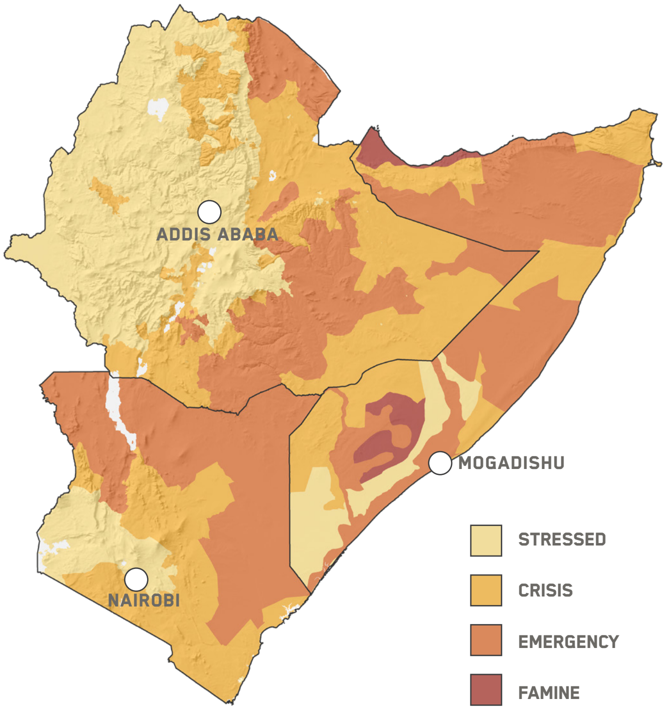
In addition to understanding conflict zones and security, locust control measures must also consider those locations that have pre-existing food insecurity. Locust-related crop destruction is especially problematic for areas already in distress from severe weather and the COVID-19 pandemic. This was the case for large parts of Ethiopia, Kenya and Somalia prior to the arrival of locust swarms in the fall of 2019, and remains the same today.

The map on the bottom right was also added to the vulnerability model and depicts the region's varying levels of food insecurity between October 2019 and January 2020. The data was obtained from the Family Early Warning System Network (FEWS Net).

VIOLENT CONFLICT EVENTS
(January 2019 - May 2020)



FOOD INSECURITY
(October 2019 - January 2020)



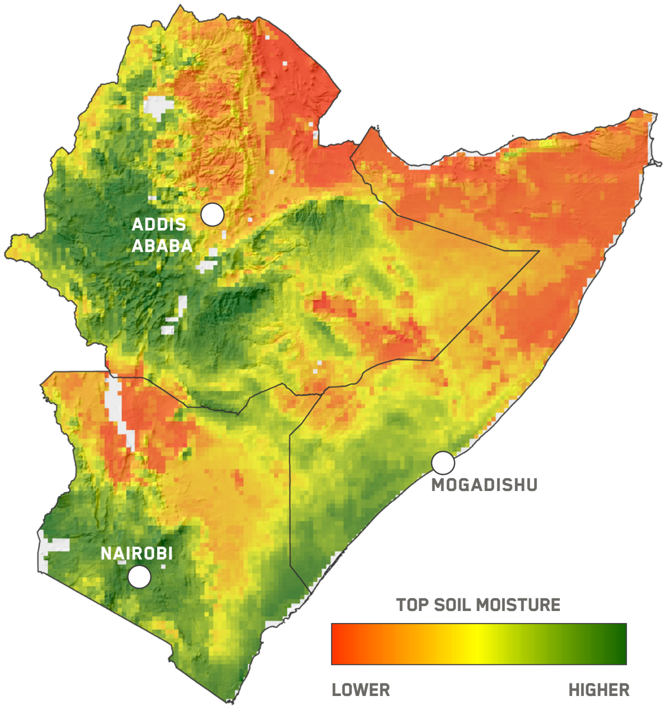
SOIL CHARACTERISTICS

Understanding soil characteristics is essential for preventing and controlling locust swarm damage. Preferred locust breeding locations feature wet and warm climate conditions, typically in areas with sandy soil that have moisture extending between 5 and 10 centimeters below the surface. By identifying locations with these overlapping and ideal soil and weather conditions, potential breeding areas can be targeted more precisely, conserving resources and potentially also reducing the amount of pesticides applied to a given area.

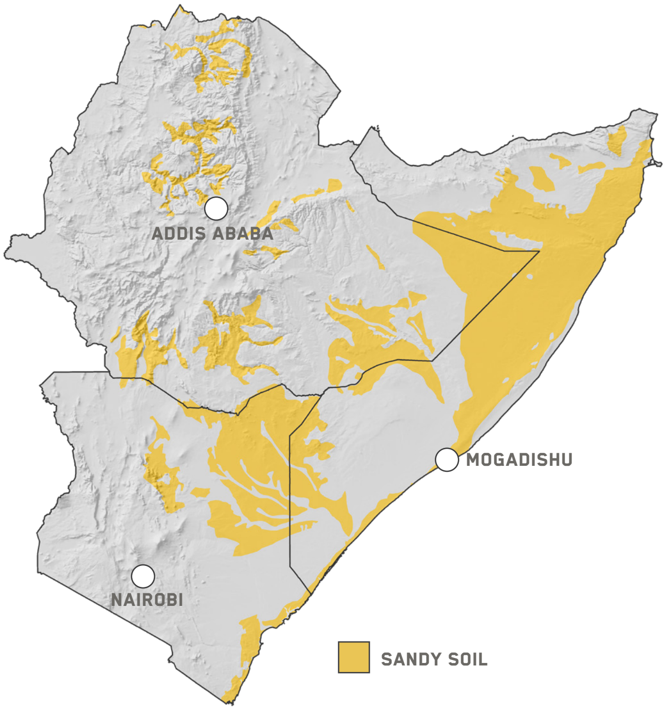
Individual soil specific layers that were applied to the aggregate vulnerability model include a sandy soil polygon dataset from Maxar Human Landscape (bottom left) and a soil moisture index from Maxar Global Weather Interactive (top right). The soil moisture index is calculated as a function of both soil type and volumetric soil water.

In terms of predicting ideal locations for the development of future swarms, it is important to mention that current soil moisture conditions in South Sudan are also favorable for locust egg laying (bottom right). This substantiates concerns about the migration of locust swarms in Ethiopia, Kenya and Somalia, which the FAO predicts will move towards Sudan and South Sudan.

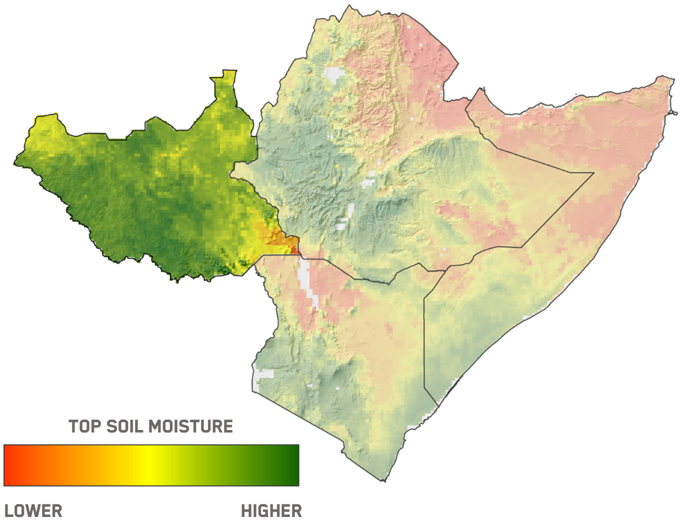
SOIL MOISTURE INDEX (May 16, 2010)



SANDY SOIL



SOUTH SUDAN SOIL MOISTURE INDEX



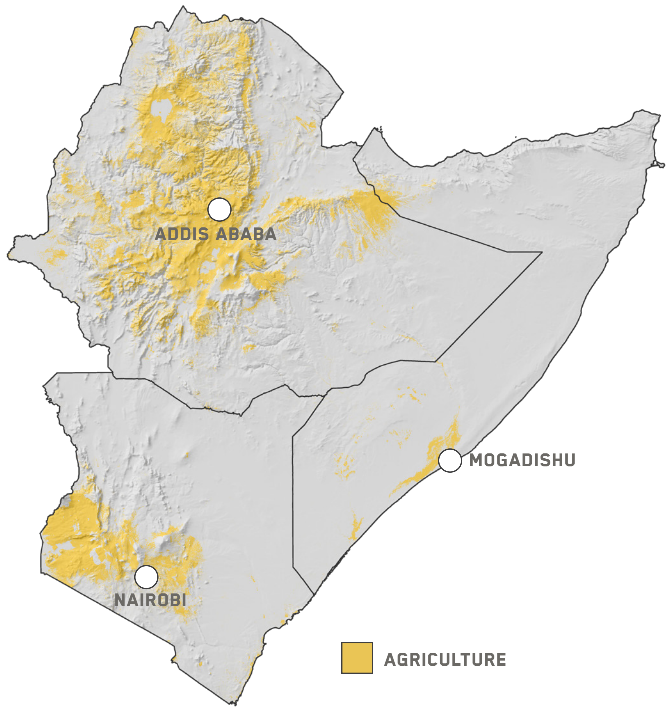
LAND USE LAND COVER

Identifying areas used specifically for agriculture is also important for preventing damage to essential food crops and mitigating the level of food insecurity cause by locusts. In some instances, locusts may even be more likely to damage agriculture crops or pastoral lands than uncultivated vegetation, according to a peer-reviewed survey of scientific literature on locust behavior by Gall, Overson and Cease published in 2019. While the review specifically examined South American locusts, they have similar behavior and appetite patterns to the desert locusts found in East Africa.

According to the review, when locusts have transformed into the gregarious phenotype, they prefer carbohydrate-rich plant matter to plants high in protein. In areas that have been consistently over-farmed, nitrogen and other nutrients become less present in the soil over time. This results in lower protein levels and a higher carbohydrate presence.

Locusts' predilection for carbohydrate-rich plants makes them more likely to damage agriculture than areas containing native vegetation and groundcover. To reflect this in the vulnerability model, agricultural areas were obtained from Maxar BaseVue, a standard global land cover dataset.

AGRICULTURAL AREAS



> **"[Historically], humans have perceived themselves as passive victims of these locust swarms that appear from nowhere and darken the skies. And this connection to nutrition sort of illuminates a different dimension to this, in that we might be more active players as humans in the complex dynamics of locusts swarming."**

- DR. RICK OVERSON | RESEARCH COORDINATOR FOR THE GLOBAL LOCUST INITIATIVE AND SENIOR SUSTAINABILITY SCIENTIST AT ARIZONA STATE UNIVERSITY'S JULIE ANN WRIGLEY GLOBAL INSTITUTE OF SUSTAINABILITY

CONCLUSION

East Africa is facing a major humanitarian crisis as a result of the region's persistent food insecurity and the combined impacts of desert locusts, COVID-19 and extreme weather. Striving to improve the health and sustainability of our planet and the people who call it home, Maxar's Earth Intelligence capabilities can augment international assistance efforts and help advise field operators to reduce the impact of the desert locust. The utilization of remote sensing techniques and geospatial modeling is more important than ever to efficiently monitor and target ideal breeding locations, forecast potential locust swarm movements and evaluate agricultural damage.

FOR A BETTER WORLD

Maxar is a trusted partner and innovator in Earth Intelligence and Space Infrastructure. We deliver disruptive value to government and commercial customers to help them monitor, understand and navigate our changing planet; deliver global broadband communications; and explore and advance the use of space.

Our unique approach combines decades of deep mission understanding and a proven foundation of commercial technology to deliver solutions with unrivaled speed, scale and cost-effectiveness.

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