Materials Research Proceedings 69 (2026) 1054-1058 https://doi.org/10.21741/9781644904251-182

Remote sensing use in Insurance Companies to Manage Natural Disasters Policies – IRIDE Constellation Case Study

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Keywords: Earth Observation, Insurance, IRIDE, Natural Disasters, Remote Sensing

Abstract. The increasing frequency and severity of natural disasters pose significant challenges to the insurance industry, which requires innovative approaches to risk assessment and policy management. This paper explores the role of remote sensing in improving the ability of insurance companies to manage natural disaster policies, with a specific focus on the IRIDE constellation. Using services designed through satellite imagery and geospatial data, insurers can better understand risk exposure and improve their response strategies. Remote sensing technologies offer the advantage of monitoring large areas with high precision, detecting changes in land use, water levels, and atmospheric conditions that can influence insurance claims. This study aims to analyze how remote sensing helps insurers prepare for and respond to catastrophic events, focusing in particular on the use of IRIDE for the scope.

Introduction

The increasing frequency and intensity of natural disasters, coupled with the vulnerability of Italy's geographic and urban infrastructure, have created an urgent need for more effective disaster risk management strategies, particularly within the insurance sector. In 2023, global insured losses from natural disasters exceeded € 100 billion, a number expected to double within the decade due to climate change, according to the latest estimates from the Swiss Re Institute. Despite this, only about 25% of Italy's natural disaster losses are insured, the public finances absorbing most of the costs; approximately € 3.5 billion annually. This alarming trend confirms the need to apply innovative tools for risk assessment, monitoring, and post-event analysis. This project explores the application of remote sensing technologies, in this instance the Italian Earth observation constellation IRIDE, to improve the operational capabilities of insurance companies in handling policies for risks and catastrophes and risk modelling.

Use of Space Technologies by Insurance Companies

The use of satellite technology in the civil and commercial sectors is becoming more and more common and frequent. Therefore, many companies find themselves having to interface, along with its exponential development, with a scientific sector that is becoming less and less alien. The range of services that satellite technology can provide is becoming wider and more accessible, so the products that can be developed from it. Revenues from EO data in 2023 in the insurance and finance segment increase from approximately € 340 million to nearly € 900 million in 2033 [1].

In this context, a market analysis is conducted that highlights the strengths, weaknesses, opportunities, and threats of this business.

Several strengths of the adoption of space technologies in the insurance sector can be identified, including improved efficiency in pricing policies, the ability to offer more personalized policies at competitive prices, a reduction in insured and operational losses, and the development of new business opportunities, such as parametric insurance and community-based catastrophe insurance.

Regarding opportunities, Italian companies are now required to obtain a Natural Catastrophe Insurance policy (CATNAT), which introduces, for the first time in the Italian regulatory framework, a mandatory insurance requirement for catastrophic risks, limited to the productive sector. This development requires insurance companies to be well prepared to manage these risks in the most efficient way. Another opportunity lies in the possibility for insurance companies to establish partnerships to bridge the knowledge gap regarding Earth observation and related services. Using the data, images, and services provided by the IRIDE constellation, they can enhance their capabilities in risk assessment and management.

However, there are also several threats and weaknesses in this market, such as the innovation inertia of the insurance sector, the lack of social awareness about the need to subscribe to policies, the requirement for big data management and highly specialized skills to handle Earth observation tools, and the still limited commercial adoption of EO techniques.

Chain of Acquisition of Data, Creation and Selling of Services

The current value creation model within the EO sector follows a multi-step value chain, which can be visualized in Figure 1. The initial stage includes the data providers, comprising entities that own and operate the space and ground segments responsible for acquiring raw EO data. Subsequently, the providers of products and services act as intermediaries, leveraging advanced data processing and analytics to transform raw data into customized solutions that address specific user requirements.

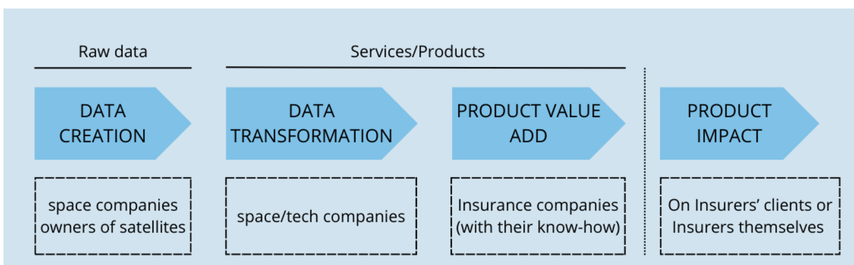

Figure 1: Value chain

Finally, in the context of this research, end users are represented by insurance companies, which use these refined data products to improve decision-making, optimize risk assessment, and streamline operational processes.

Satellite technologies can be considered a valuable investment in the insurance segment. Despite this, there are various ways to invest in this technology. In particular, companies can choose to invest in an internal team that processes raw data and transforms it into services, or they can form external partnerships with companies that have the resources and expertise to create semi-finished services to sell to insurance companies.

An Italian insurance company was interviewed, revealing the idea that it would be preferable to establish advanced partnerships, delegating the more complex aspects of satellite analysis to specialized partners. The current trend emerged leans toward integrating satellite technology into existing company processes without significantly disrupting the traditional insurance model.

Use of IRIDE Constellation

IRIDE is a satellite constellation for Earth observation initiated by the Italian Government, supported by resources from the National Recovery and Resilience Plan (PNRR). IRIDE will be completed by 2026 under the management of the European Space Agency (ESA), with the support of the Italian Space Agency (ASI). IRIDE satellites will offer 8 macro services for marine and coastal monitoring, air quality, ground motion monitoring, land cover analysis, hydro-meteorological and climate observation, water resource monitoring, emergency management, and security. In total the constellation will be composed by 6 sub-constellations, placed in Low Earth Orbits to obtain more frequent and detailed images: HEO (Multi1) and EAGLET-2 (Multi2) have a multispectral sensor, NIMBUS-VHR (Opt) an optical one, NIMBUS-SAR (SAR1) and NOX (SAR2) have on-board a SAR sensor and PLATINOHYP (Iper) a hyperspectral sensor. Each constellation is defined by the orbital parameters of the satellites and the specifications of the sensors on board [2]. Some modifications and assumptions have been applied to obtain repeating ground tracks and improve coverage, following the system of equations 1 [3], which aims to obtain the new inclination (i) to respect the SSO requirement, and the new semi-major axis (a) to meet the periodicity constraint.

The propagation method used in the simulation is the SGP4 to compute satellites' positions and velocities; and to build a complete satellite simulation scenario, the Satellite Communications Toolbox in Matlab is adopted.

$$\begin{cases} i = cos^{-1}\left(\frac{-2\dot{\omega}_d a^{\frac{7}{2}}}{3\sqrt{\mu}J_2R_e^2}\right) \\ P_\Omega = \frac{2\pi}{n+\frac{3nR_e^2J_2\sqrt{1-e^2}}{4\left(a(1-e^2)\right)^2}(3sin^2i-2)+\frac{2-3nR_e^2J_2}{4\left(a(1-e^2)\right)^2}(4-5sin^2i)} \\ k_{rep}P_\Omega\left(1-\frac{T_E}{T_y}\right) = k_{day}T_E \end{cases} \tag{1}$$

Coverage

To assess the performance of a constellation, it is crucial to analyze the number of days required to achieve meaningful coverage. The methodology used will take into account the exact area observed by each sensor type considering both the direction of the sensor and the acquisition mode [4].

Table 1 reports the percentages of coverage for each constellation reached in an interval of time of Italian territory. SAR1 results in being the most efficient constellation while the Optical is the least.

Table 1: Constellations' coverage

	Period [days]	**Coverage**
SAR1	6	98.93%
SAR2	15	76.87%
Opt	15	66.53%
Iper	15	83.59%
Multi1	10	82.23%
Multi2	6	94.97%

Revisit Time

Spatial coverage alone is insufficient without considering a temporal factor, which provides insights of how often and for how long the spacecraft is available within a given time frame. The goal of this analysis is to estimate and evaluate the revisit times of each constellation, ensuring that they meet the requirements of the end users.

All constellations are in Sun Synchronous Orbits (SSO) except from SAR1 which is in a Mid Inclination Orbit (MIO). For a given inclination of SSO, the revisit time decreases as the latitude increases, while SAR1 orbit is designed to have 6 satellites at 44 degrees inclination and the remaining 6 at 49 degrees, which results in having a lower revisit time around the latitude of 44 degrees, while only the 6 satellites with 49 deg inclination can access higher latitudes, resulting in less accesses to these areas.

Optical and SAR2 constellations have the highest revisit time due to their limited number of satellites. Additionally, the revisit time of each constellation depends much more on latitude than on longitude.

Ground Station Access

The primary purpose of Earth observation satellites is to collect data, such as imagery or environmental metrics. Ground stations receive this data via down-link for processing, analysis, and distribution. In the study of the link with ground stations, only those located within European territory are considered. It has been verified that satellites, after acquiring and processing images and data over Italy, can transmit and communicate with ground stations within Italian territory almost instantaneously (e.g. for the transmission of 1GB, see Equation 2, while remaining visible for the required duration. In fact, the duration of a typical communication session with a single satellite from one of the IRIDE constellations ranges between 6 and 8 minutes, which is sufficient for data transmission.

$$T = \frac{1GB(8Bit)}{400Mbps} = 20s \qquad (2)$$

Requirements and IRIDE's adaptability for specific case studies of natural disasters

The events considered in this study are earthquakes, landslides, floods, fires, and critical infrastructure. For each event, the necessary requirements for their observation through remote sensing are investigated, as reported in Table 2 and retrieved from past literature. For each event, the most suitable IRIDE constellations are selected based on the requirements listed above. While resolution (Res) and sensor type are easily met, a more detailed analysis is conducted for revisit time (RT), identifying critical locations for each case study and evaluating them over a long time interval. When the use of the SAR1 constellation is required, it meets all requirements thanks to its high spatial and temporal efficiency. In contrast, the optical and hyperspectral constellations almost always require integration with external satellites due to their high revisit time, which does not meet the necessary requirements. Additionally, the combined use of MULT1 and MULT2 is sufficient for studying events requiring multispectral observation.

Table 2: Requirements for events' observation

	Sensor	Res [m]	RT [days]
Earthquakes	Optical SAR	5 20	1-7
Landslides	Optical Multi & InSAR	1 10	5
Floods	Optical SAR Multi	1-5 300 30	1-3 <1
Fires	Multi Hyper	10-500 ≥30	1-5 7
Critical In.	DinSAR (spotlight)	1-5	1-7

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Conclusions

In conclusion, to scale EO for broader commercial use changes in data collection, sale and application are required. Despite EO can facilitate various industries, its commercial adoption has been slow, particularly in the insurance sector, due to technology inertia and financial barriers.

This research highlights the IRIDE program as a key solution, providing continuous and high resolution EO data for disaster monitoring and prevention. With the additional possibility of integrating IRIDE with other external constellations, insurance companies can improve risk assessment and develop advanced models such as parametric insurance. In addition, EO will complement, rather than replace, existing methods like in-situ sensors and drones, creating a comprehensive risk management approach.

As extreme weather events increase, creating partnerships between space agencies, insurers, and technologies providers will be crucial for maximizing EO's potential in disaster resilience.

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