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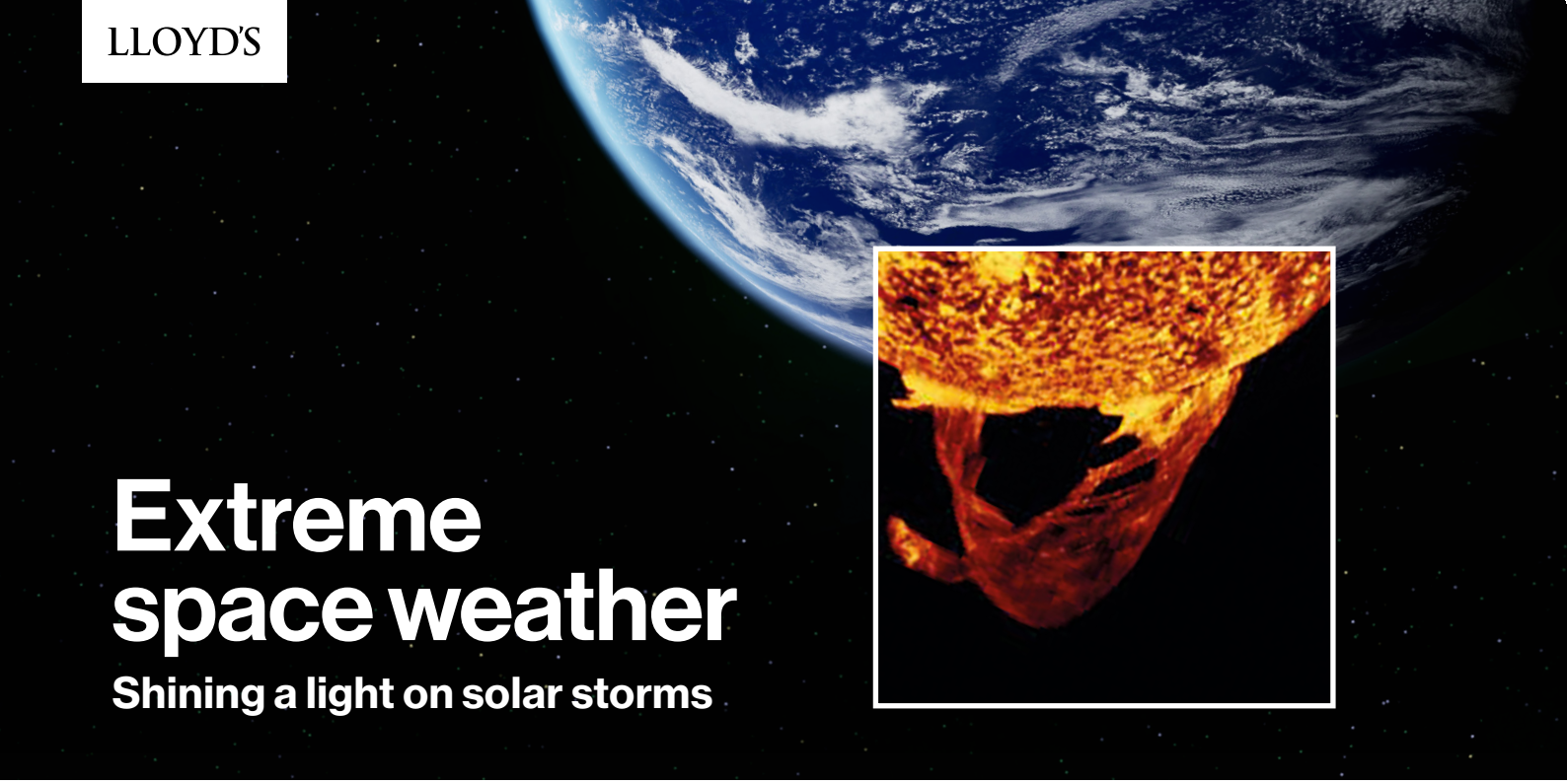

Extreme space weather

Shining a light on solar storms

A solar storm is a sudden and intense burst of radiation and energetic particles blasted from the Sun. If large enough and directed towards Earth, the resulting 'space weather' has the potential to severely damage critical infrastructure and create significant disruption across multiple industries and our everyday activities.

Picture the scene: A major solar storm unfolds

Sighting: Solar scientists at an observatory see increased sunspot activity, highlighting a potential threat to Earth. Governments and critical infrastructure operators are alerted.

Eruption: High solar activity continues, resulting in a release of energy that sees very large coronal mass ejections (CMEs) thrown out towards Earth.

Bombardment: For an hour Earth is hit with a geomagnetic storm, this is joined by numerous substorms forming every few hours on the daylight side of the planet.

Interference: The build-up of charged particles trapped within the Earth's magnetic field causes signal scintillation which inhibits communication signals from satellites.

Stress: On Earth, the geomagnetic storm induces high electric currents along electricity cables, while in space the solar arrays that satellites rely on for power begin to degrade.

Burn-out: Extra high voltage (EHV) components across the energy grid are damaged beyond repair. Subsequently, nodes collapse and remaining electrical assets fold. This leads to power outages across whole regions.

Consequences: The economy takes a throttling as infrastructure fails; global aviation grinds to a halt. Copper cabling at industrial sites overheat, igniting fires. Outages across critical communication, navigation and power services.

The severity of events and impact

Not every solar storm will create such widespread disruption. There are differing levels of severity - from a major event that causes localised and temporary system errors and outages, to extreme events that may be much longer lasting and have the potential to paralyse critical infrastructure systems worldwide.

Level	Scenario severity descriptions	Historical reference
Major	**Strong geomagnetic storm:** Planes and passengers at high altitude may be exposed to limited radiation. Satellite systems have memory problems and noise on imaging systems, GNSS become prone to error, high frequency (HF) radio communications blackout. Some low-level electrical interference and voltage control problems. Less than a week of disruption.	**1989 Geomagnetic Storm**
Severe	**Severe geomagnetic storm:** Planes and passengers at high altitude are exposed to radiation. Satellite systems have memory device problems and noise on imaging systems, GNSS are prone to error, and there is a blackout of HF radio communications. Widespread voltage problems and power grids tripping in certain regions. Over a week of disruption caused.	**1859 Carrington Event**
Extreme	**Extreme geomagnetic storm:** Large radiation exposure to passengers and crew in commercial jets at high altitude. Satellites rendered useless, GNSS failure and serious noise on imaging systems is seen. Telecommunication systems fail and widespread voltage control and protective system problems occur. Some grid systems experience complete collapse or blackouts. Transformers may experience damage. Several weeks of disruption before systems are back online.	**2012 solar superstorm that missed Earth**

$2.4trn

Potential global economic loss from extreme space weather

How vulnerable is the economy?

If a major solar storm were to take place, the global economic impact could, based on our calculations, reach **$2.4 trn** over a five-year period (this represents the probability weighted average across the three severities we have modelled), with an expected loss of **$17 bn** (the economic loss multiplied by the probability of the event occurring).

Which sectors might be most at risk?

Space: Nearly every industry and business across the world relies on the day-to-day operation of satellites. A solar storm increases the risk of satellite drag or collision, which could render satellites unusable.

Communications: Communications underpin many economic activities but key infrastructure and transmissions can be severely hampered by a solar storm. Communications are also dependent on power supply to ground segment systems. In extreme solar storm events data centres could suffer data corruption and memory malfunction.

Energy: Energy grids are very vulnerable to outages due to space weather. If the grid is working at full tilt with little capacity to spare, an outage can leave customers without power for some time until systems are repaired.

Transport: Reliance on satellites for power, communications and GNSS mean the rail, road, maritime and aviation sectors are all at risk. Supply chains across all industries would be impacted.

Agriculture: GNSS is crucial for modern agricultural practices. A failure in navigation satellites can disrupt these activities, leading to reduced efficiency and potential financial losses.

Financial services: Many critical financial systems rely on GNSS to conduct transactions worldwide. The disruption to global financial market flows could impact financial liquidity and erode public trust in banks.

What can businesses do?

Preparedness: Businesses response plans should consider including education and monitoring of space weather forecasts, to recognise when a solar storm is more likely; crisis response drills for a range of scenarios; and risk assessments for the most business-critical application and power infrastructure.

Contingencies: Establishing back-up generators and energy sources separate to the main grid, such as solar panels and storage batteries, can reduce any dependency on the local grid and tide critical locations over until repairs are made.

Safeguards: Software and data can be corrupted, or hardware can be damaged. Businesses would be well advised to create backup systems, ideally with auto-save functions, implement surge protections to prevent burn out, and embed rigorous cybersecurity.

Next steps

Work proactively to build resilience in your risk management against these threats and connect with your broker to discuss risk transfer for solar storms.

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