Resilience in Engineering Design

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THE FONT OF KNOWLEDGE

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GOVERNMENT OF
WESTERN AUSTRALIA
DFES
Department of Fire &
Emergency Services
COMMUNICATION
SUPPORT UNIT


$3.50 | Saturday, July 20, 2024
The West Australian
:(
COMPUTER SAYS NO
The IT hits the fan: How a simple tech glitch shut down the world
FULL COVERAGE PAGES 3-7

FIVE NINES AVAILABILTY 99.999%

Availability %	Downtime (per year)
90 % (one nine)	36.5 days
99 % (two nines)	3.65 days
99.9 % (three nines)	8.75 hours
99.99 % (four nines)	52.56 minutes
99.999 % (five nines)	5.26 minutes

Calculating Downtime

- So for 99.999% uptime (5 nines) – the downtime in minutes/year
- (365 x 24 x 60)/0.00001
- = 5.256 Mins/ year (about 45 secs per month)

What impacts on system availability

- Human Error
- Machine failure
- Cyber attack
- Physical attack
- Weather events
- Out of support (no spares)
- Financial concerns
- Failure of external sources
  - Power
  - Cooling
  - Communications – system interconnection
  - Timing and synchronisation signals

Black Swan Event

The event is a surprise (to the observer).

The event has a major impact.

After the first recorded instance of the event, it is rationalized by hindsight, as if it could have been expected

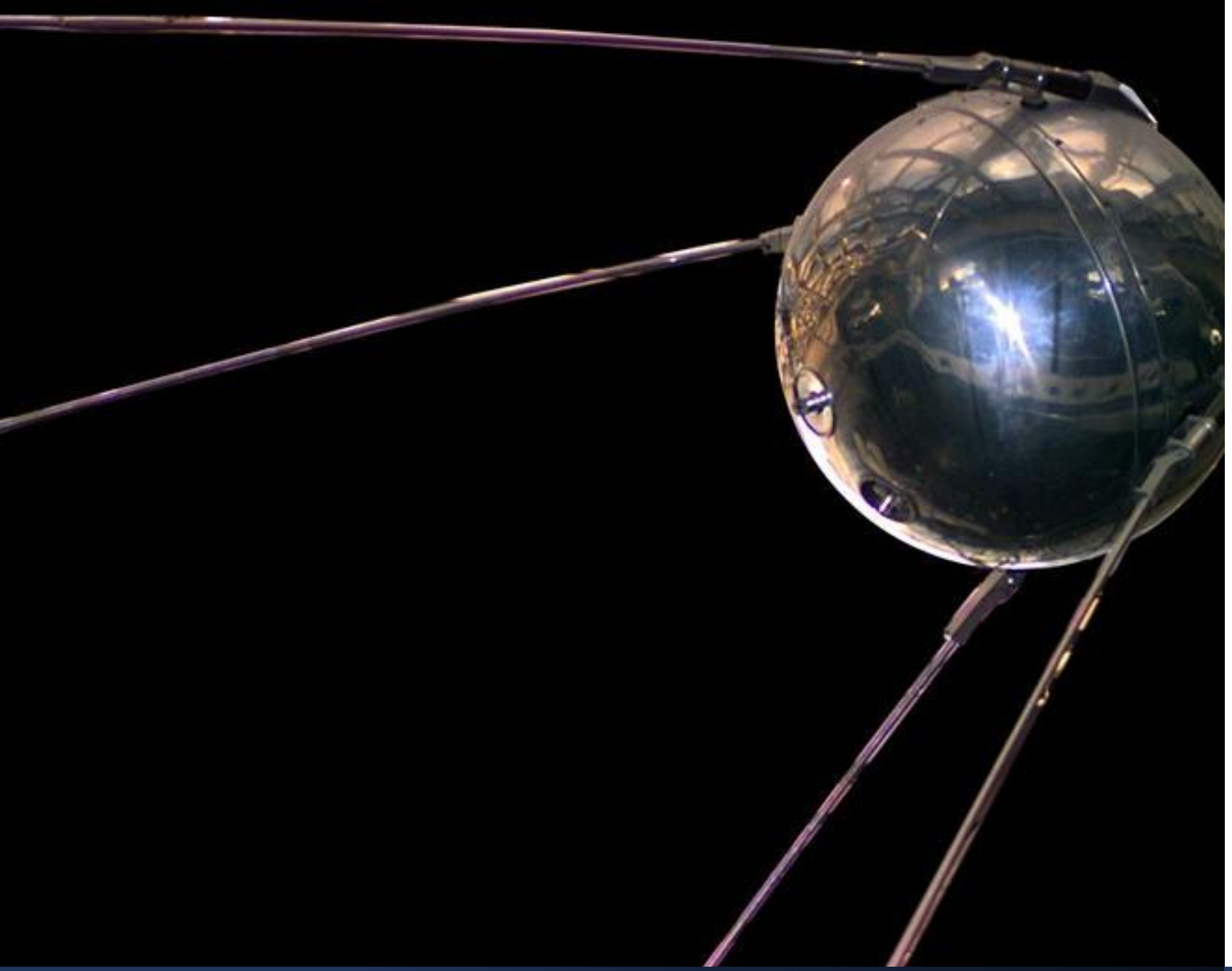
Space Domain Awareness – is the study and monitoring of satellites and other items that are in the earth's orbit.

These objects consist of active and deactivated satellites, spent rocket components and fragmentation debris.

…… *and it is growing daily*.

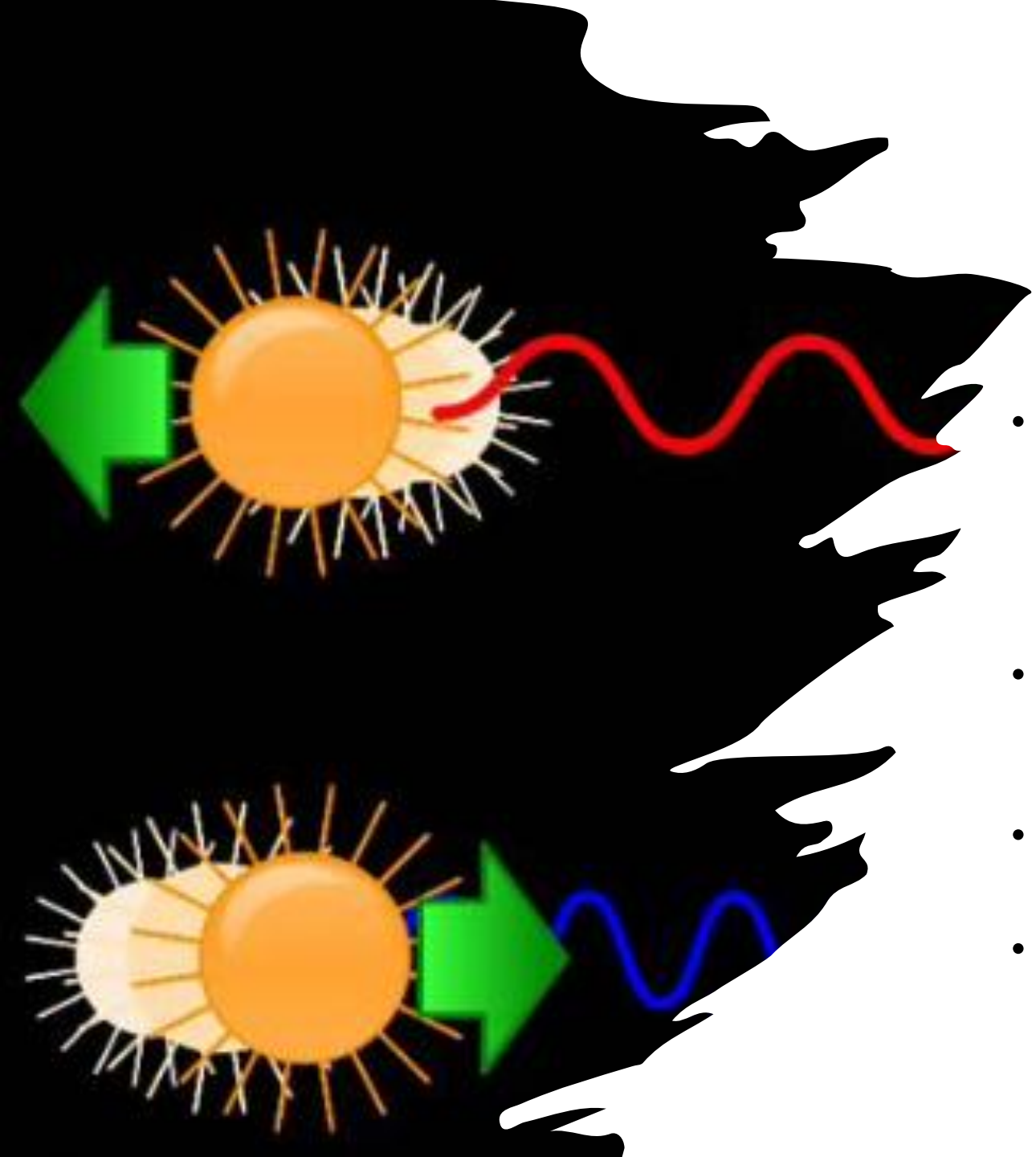
- **LEO** – Low Earth Orbit is the earth orbit with an altitude of 2000kms or less.

The *International Space Station* and *Hubble telescope* are located within LEO, as well as other communications and scientific satellites.



On the 4th Oct 1957 the Soviet Union launched the worlds first artificial satellite *Sputnick 1*.

This marked the start of “The Space Race”.



Tracking of based space objects

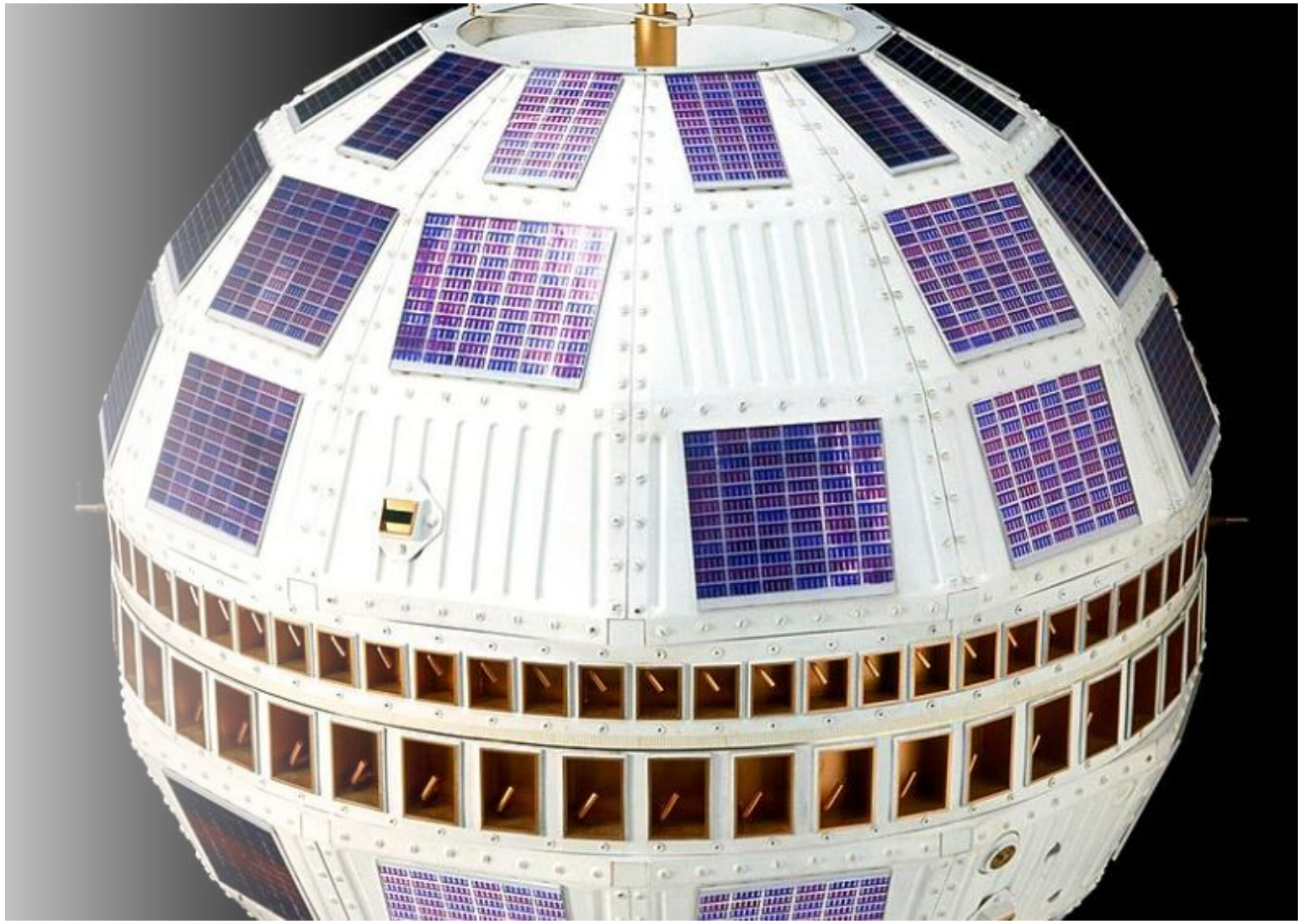
- When the Soviet Union launched Sputnik 1, two American physicists, William Guier and George Weiffenbach, at Johns Hopkins University's Applied Physics Laboratory decided to monitor its radio transmissions.
- Within hours of the launch, they realized that because of the Doppler effect, they could pinpoint where the satellite was along its orbit
- Doppler shift (blue/red) is used to determine the location of space objects.
- This research led to the development of GPS systems.

Telstar 1

The USA successfully launched TELSTAR 1 in July 1962, supporting the first live TV broadcasts – it was the first commercial payload

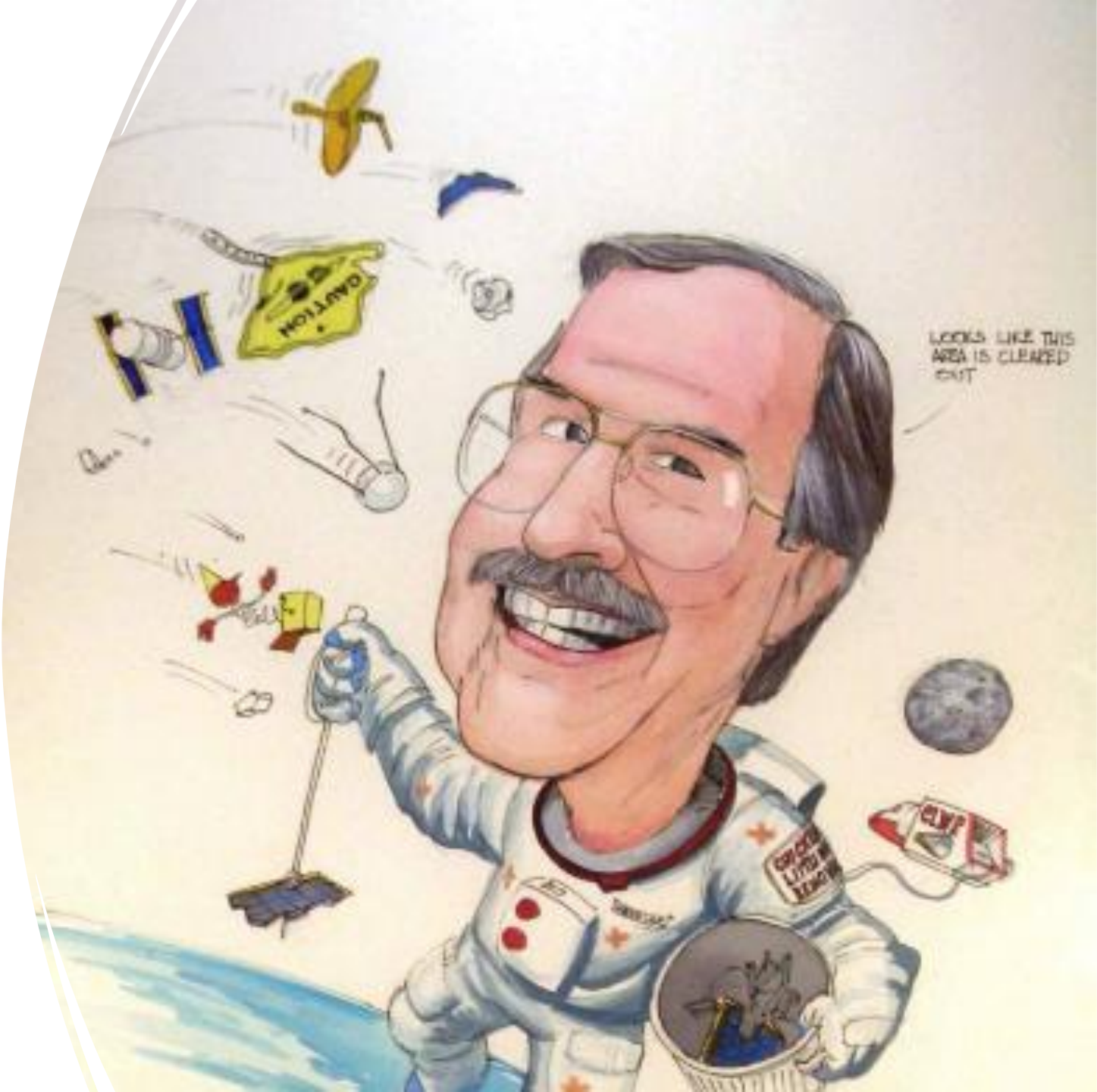
It remained operational for 7 months before succumbing to damage due to exposure to a high-altitude nuclear test. (Starfish Prime)

Despite it is no longer functioning – it remains in orbit to this day.

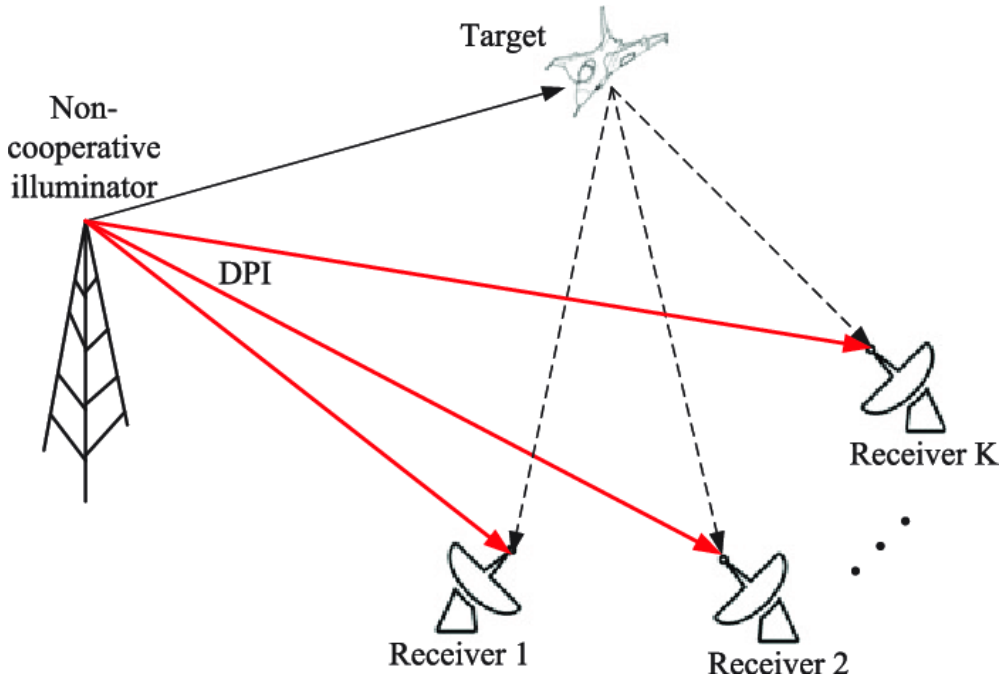


Kessler Syndrome

In 1978 NASA scientist Donald Kessler proposed that two colliding objects in space generate more debris, that then collides with other objects, creating even more shrapnel and litter until the entirety of LEO is an impassable array rending the region unusable for reliable space use.

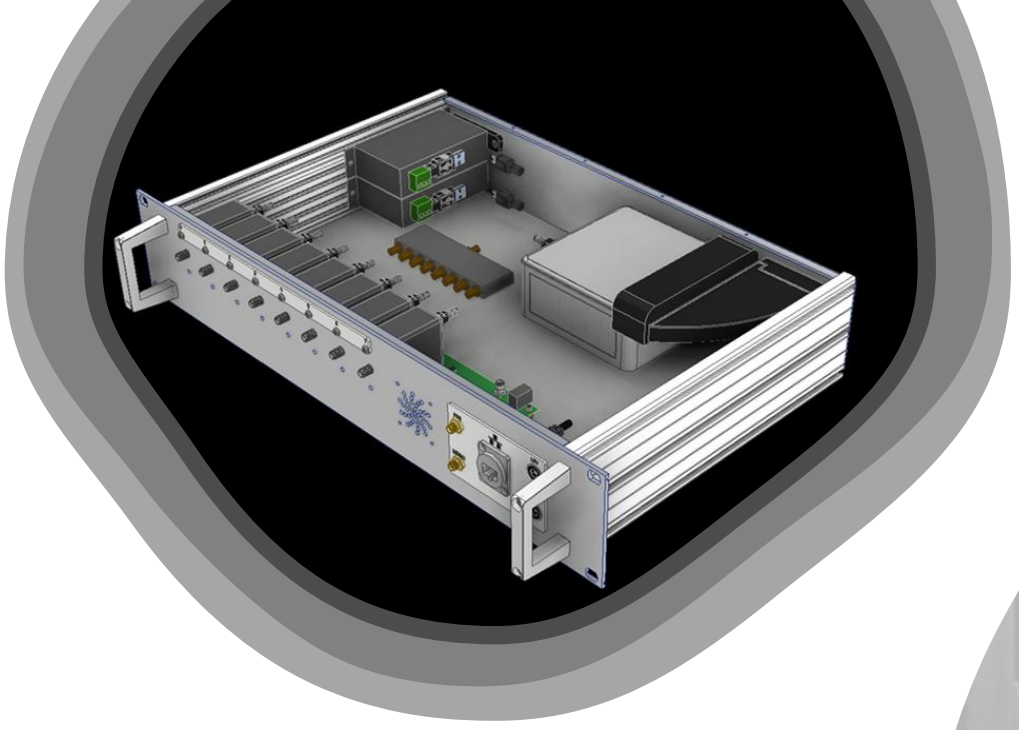


Space Domain Awareness. (My Project)



In a passive radar system, there is no dedicated transmitter.

Instead, the receiver uses third-party transmitters in the environment, and measures the time difference of arrival between the signal arriving directly from the transmitter and the signal arriving via reflection from the object.



In house development and manufacture of custom-made passive radar equipment.


SDA PoC
INJECTOR

News Headlines – Tue 23 Aug, 22

A Russian SOZ rocket motor has exploded in space releasing potentially hazardous debris fragments – the engine remains are likely to re-enter the atmosphere, but that may take years or decades!

2,000 active satellites in Earth's orbit

3,000 dead satellites in Earth's orbit

34,000 pieces of space junk larger than 10 centimetres

128 million pieces of space junk larger than 1 millimetre

One in 10,000: risk of collision that will require debris avoidance manoeuvres

25 debris avoidance manoeuvres by the ISS since 1999

What else is there in space?

- a glove lost by astronaut Ed White on the first American space-walk
- a camera lost by Gemini 10 pilot Michael Collins, and another by Sunita Williams of STS-116 during a space-walk
- a thermal blanket lost during STS-88 mission,
- garbage bags jettisoned by cosmonauts during Mir's 15-year life (including frozen human waste)
- a toothbrush.
- a pair of pliers, a spanner and during a spacewalk astronaut Heidemarie Stefanyshyn-Piper lost a briefcase-sized tool bag.

What else is there in space?

Other risks come from micrometeoroids, such as the damage to the *Space Shuttle Challenger's* front window.

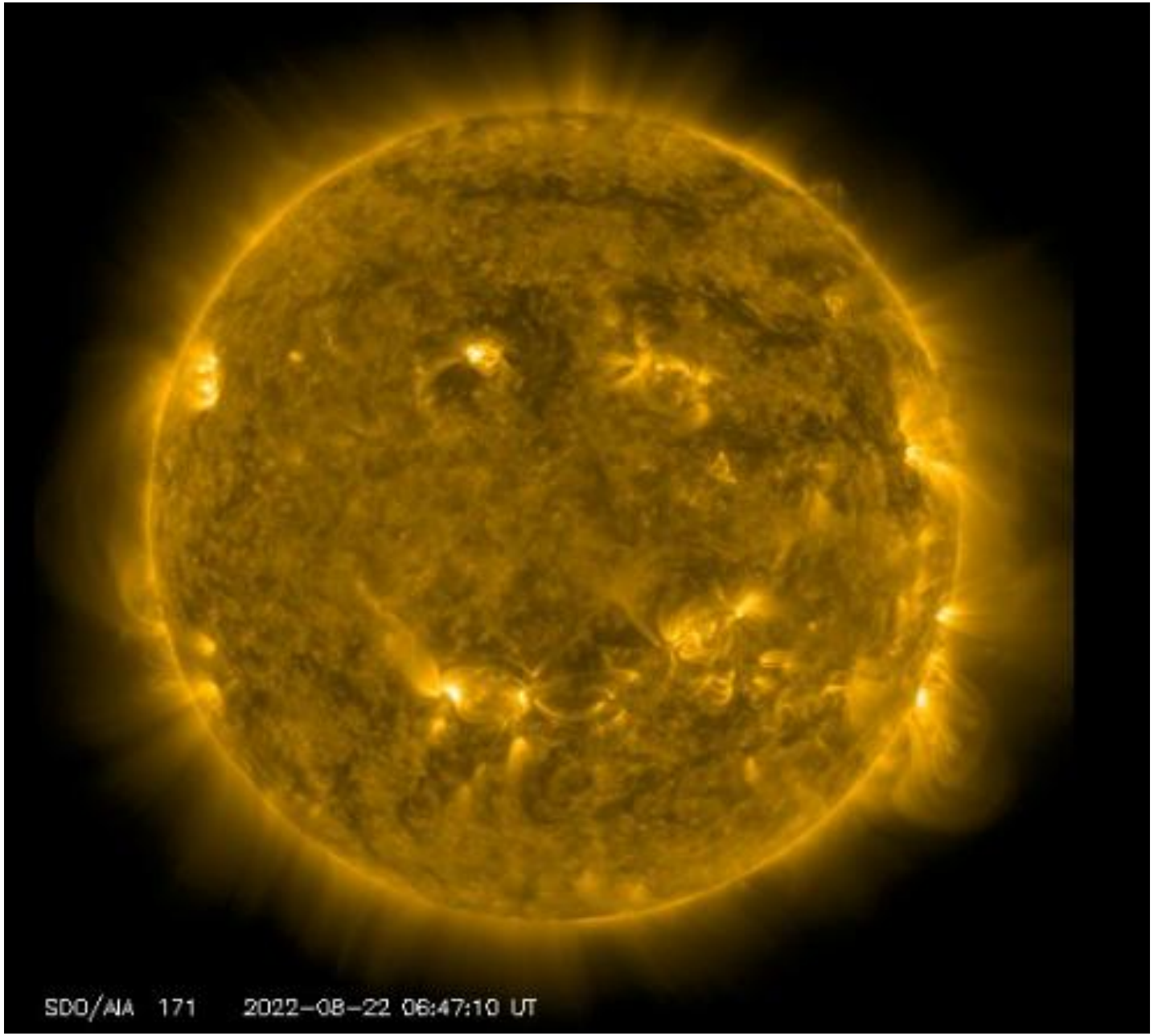
Growth of Space Items

Non-governmental organisations such as SpaceX and Amazon, plan to launch thousands of satellites to achieve global satellite internet coverage.

If successful, there could be an additional 50,000 satellites in orbit.

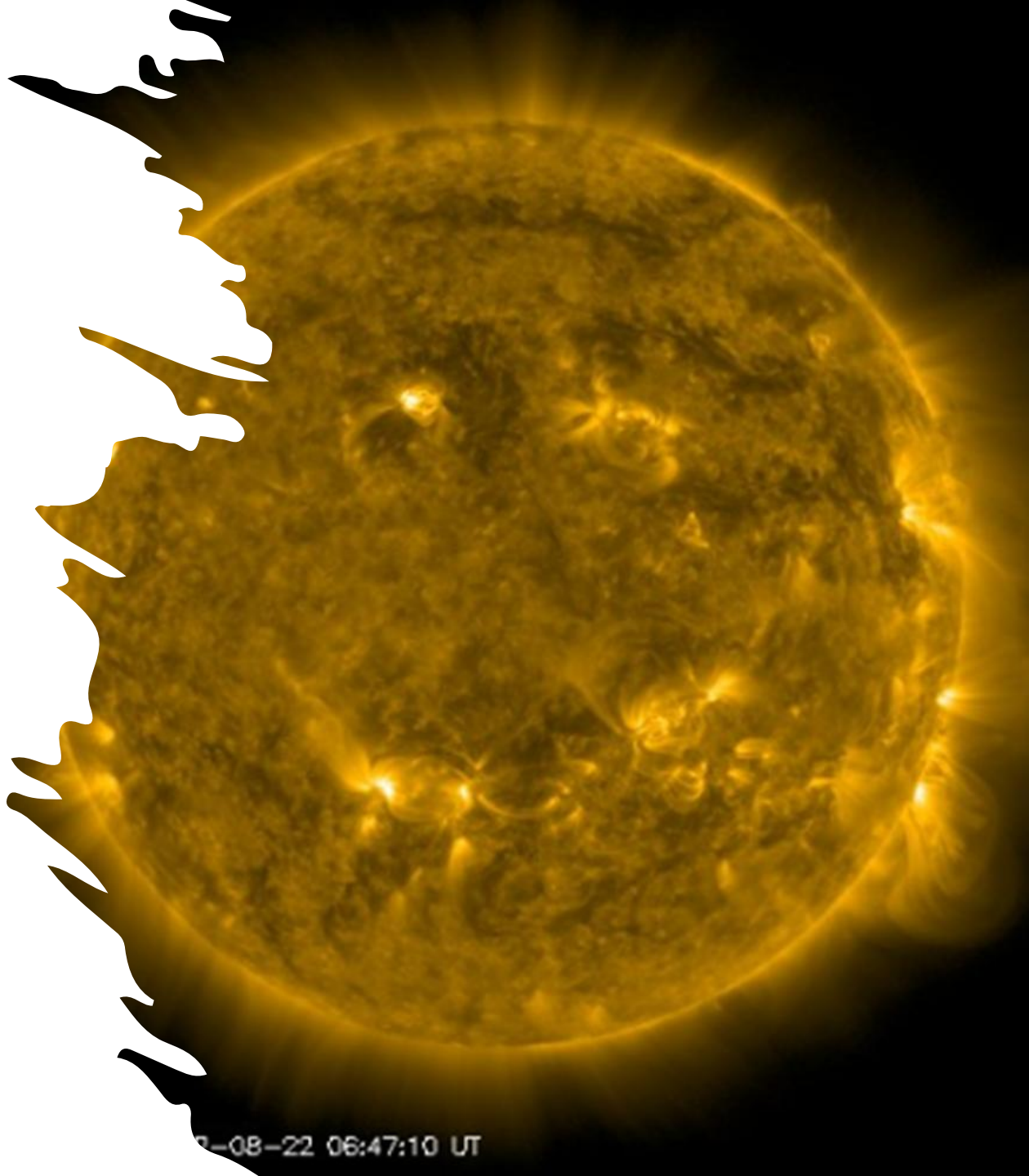
This also means a lot more collision avoidance manoeuvres will need to be made.

Space Weather



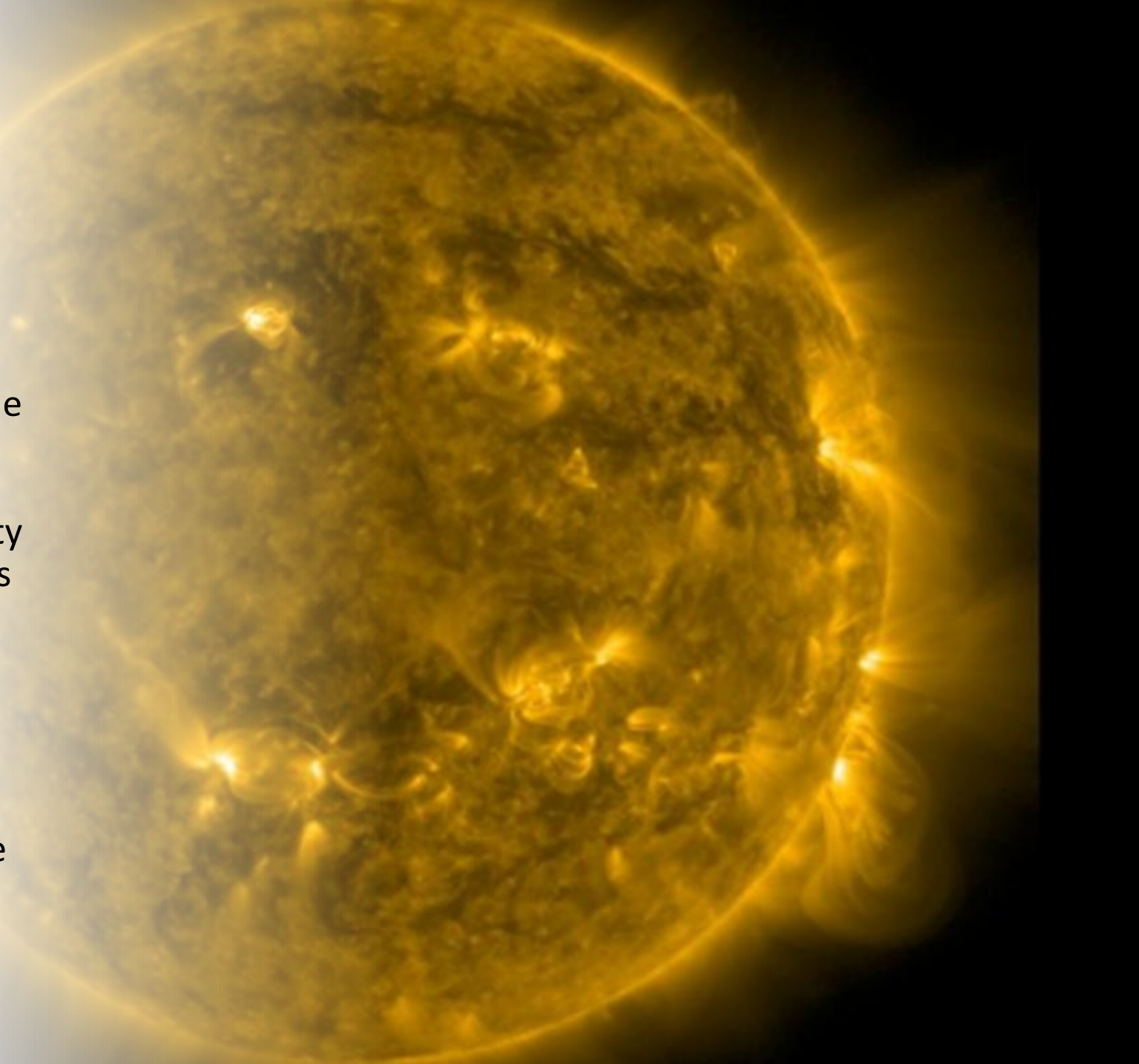
Space Weather

- Space weather refers to events beyond the Earth's atmosphere that impact upon our technology and the near-Earth space environment.
- The primary source of space weather is the sun, with the greatest disturbances usually caused by solar flares and subsequent geomagnetic storms.
- These can impact on technologies in the near-Earth space environment, including satellites, terrestrial communication systems, power grids and aviation services.



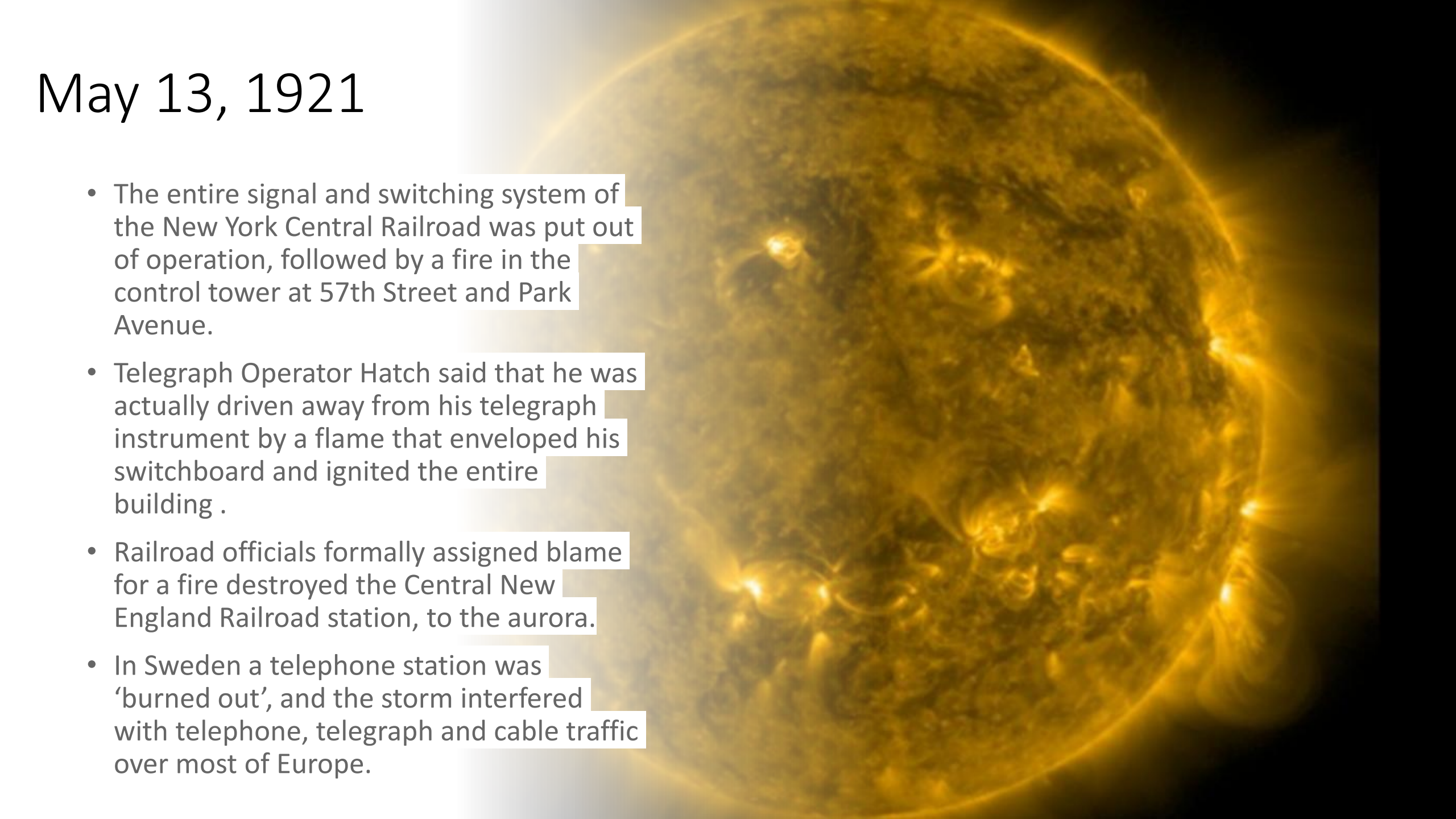
Carrington Event

- In Sept 1859, telegraph systems around the world failed catastrophically. The operators of the telegraphs reported receiving electrical shocks, telegraph paper catching fire, and reported the ability to operate equipment with batteries disconnected.
- During the evenings, the aurora borealis, more commonly known as the northern lights, was visible at much lower latitudes, whereas typically, these lights are only visible at higher latitudes, in northern Canada, Scandinavia and Siberia.



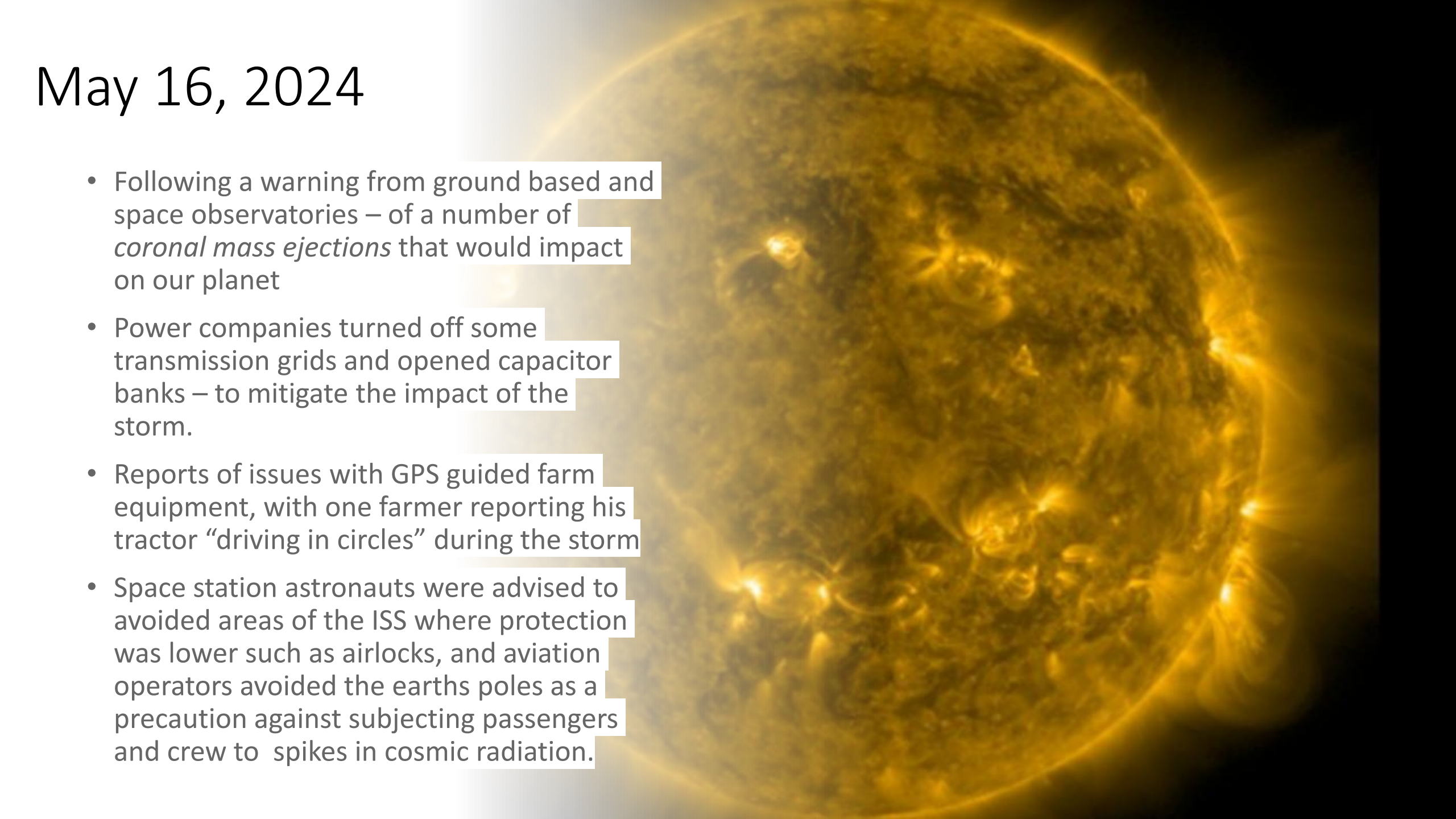
May 13, 1921

- The entire signal and switching system of the New York Central Railroad was put out of operation, followed by a fire in the control tower at 57th Street and Park Avenue.
- Telegraph Operator Hatch said that he was actually driven away from his telegraph instrument by a flame that enveloped his switchboard and ignited the entire building .
- Railroad officials formally assigned blame for a fire destroyed the Central New England Railroad station, to the aurora.
- In Sweden a telephone station was ‘burned out’, and the storm interfered with telephone, telegraph and cable traffic over most of Europe.



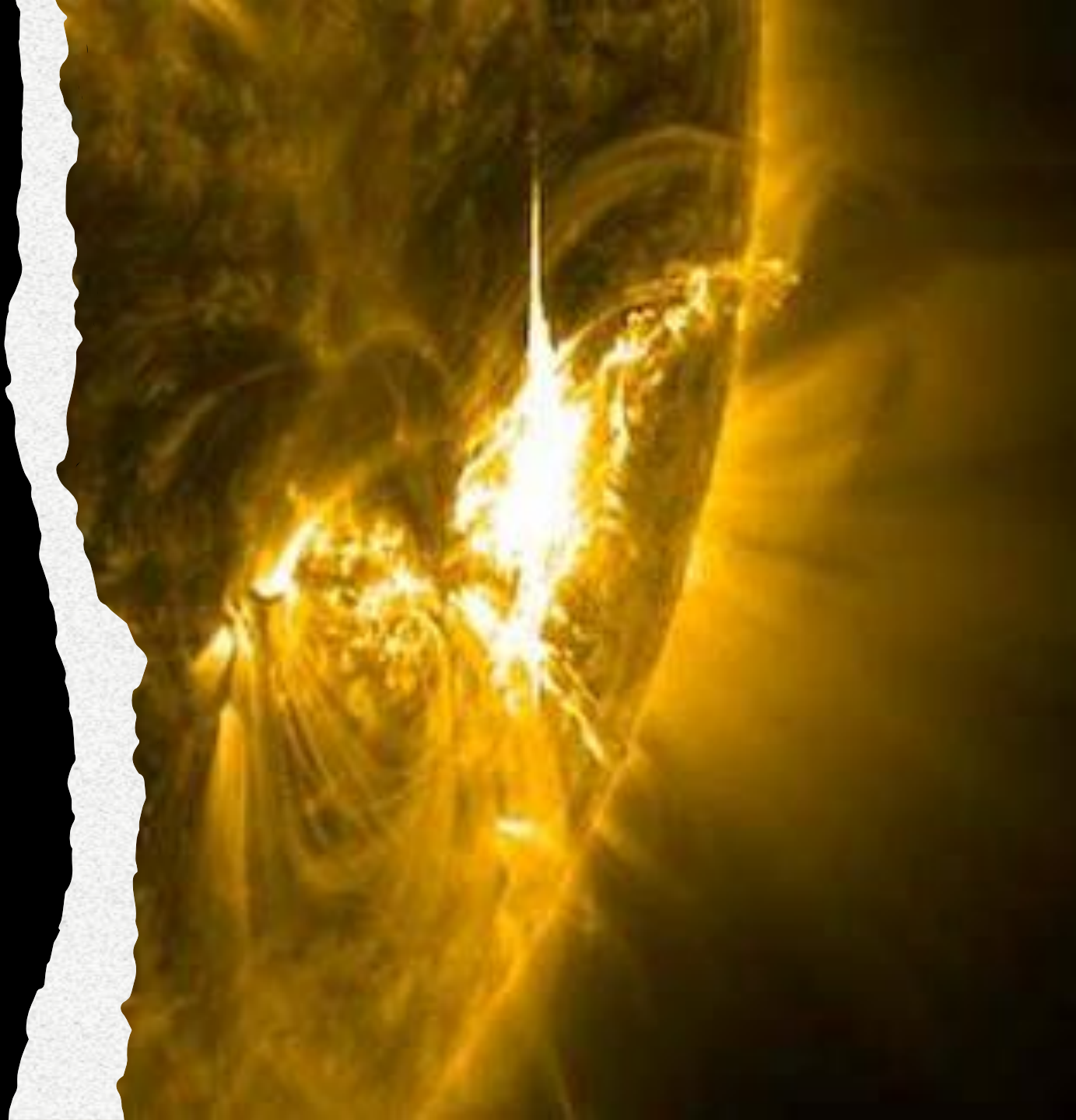
May 16, 2024

- Following a warning from ground based and space observatories – of a number of *coronal mass ejections* that would impact on our planet
- Power companies turned off some transmission grids and opened capacitor banks – to mitigate the impact of the storm.
- Reports of issues with GPS guided farm equipment, with one farmer reporting his tractor “driving in circles” during the storm
- Space station astronauts were advised to avoided areas of the ISS where protection was lower such as airlocks, and aviation operators avoided the earths poles as a precaution against subjecting passengers and crew to spikes in cosmic radiation.



Magnetospheric Storms are expressed in nanoteslas (nT) with a baseline measurement of the Earth's Magnetic field -20 nT.

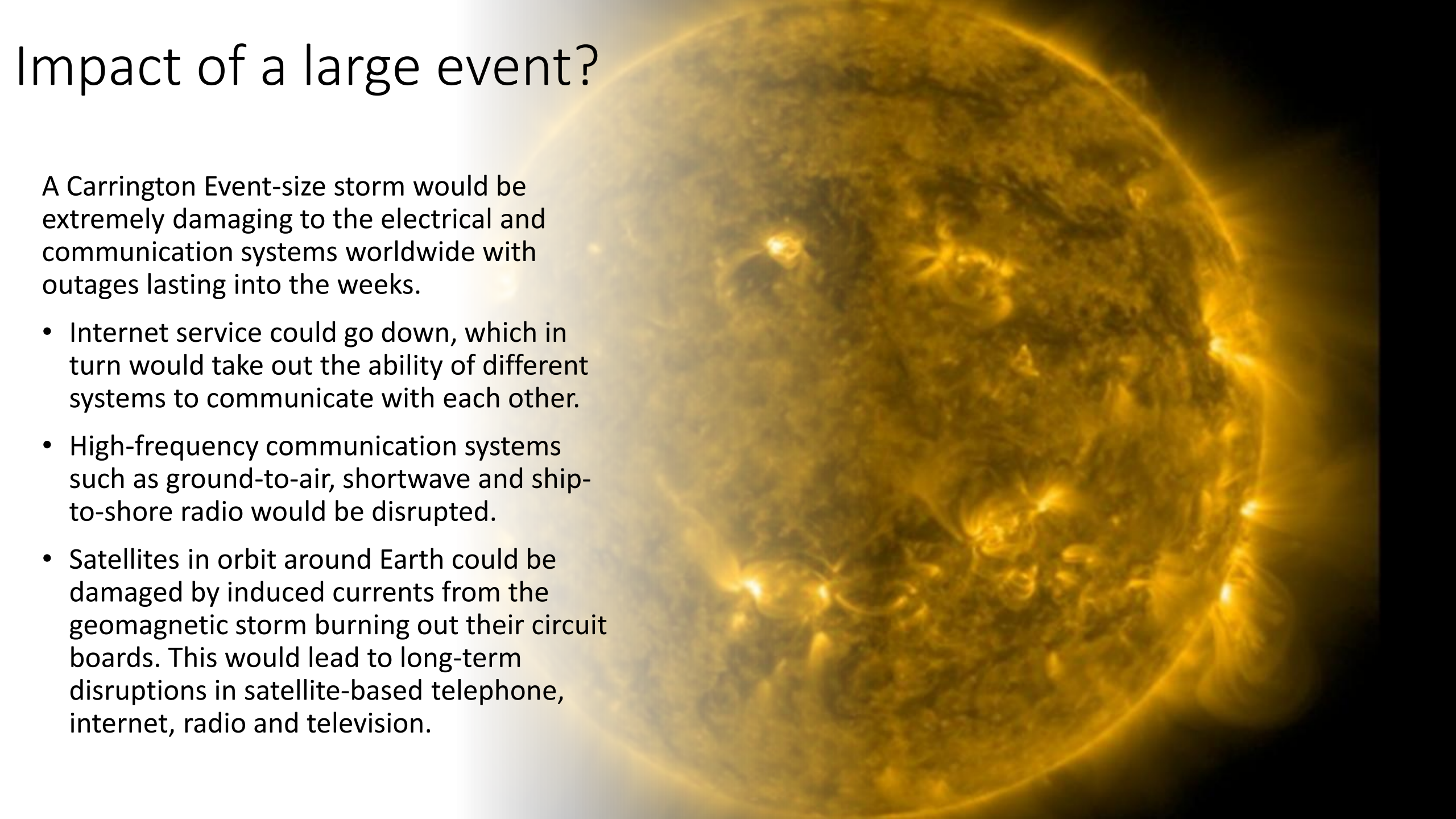
- The recent storm (May 2024) magnitude was recorded as – 412nT.
- The New York Railroad Storm of 1921 was around - 900 nT.
- The Carrington Event of 1859 was likely to have been in the region of – 1,750nT.



Impact of a large event?

A Carrington Event-size storm would be extremely damaging to the electrical and communication systems worldwide with outages lasting into the weeks.

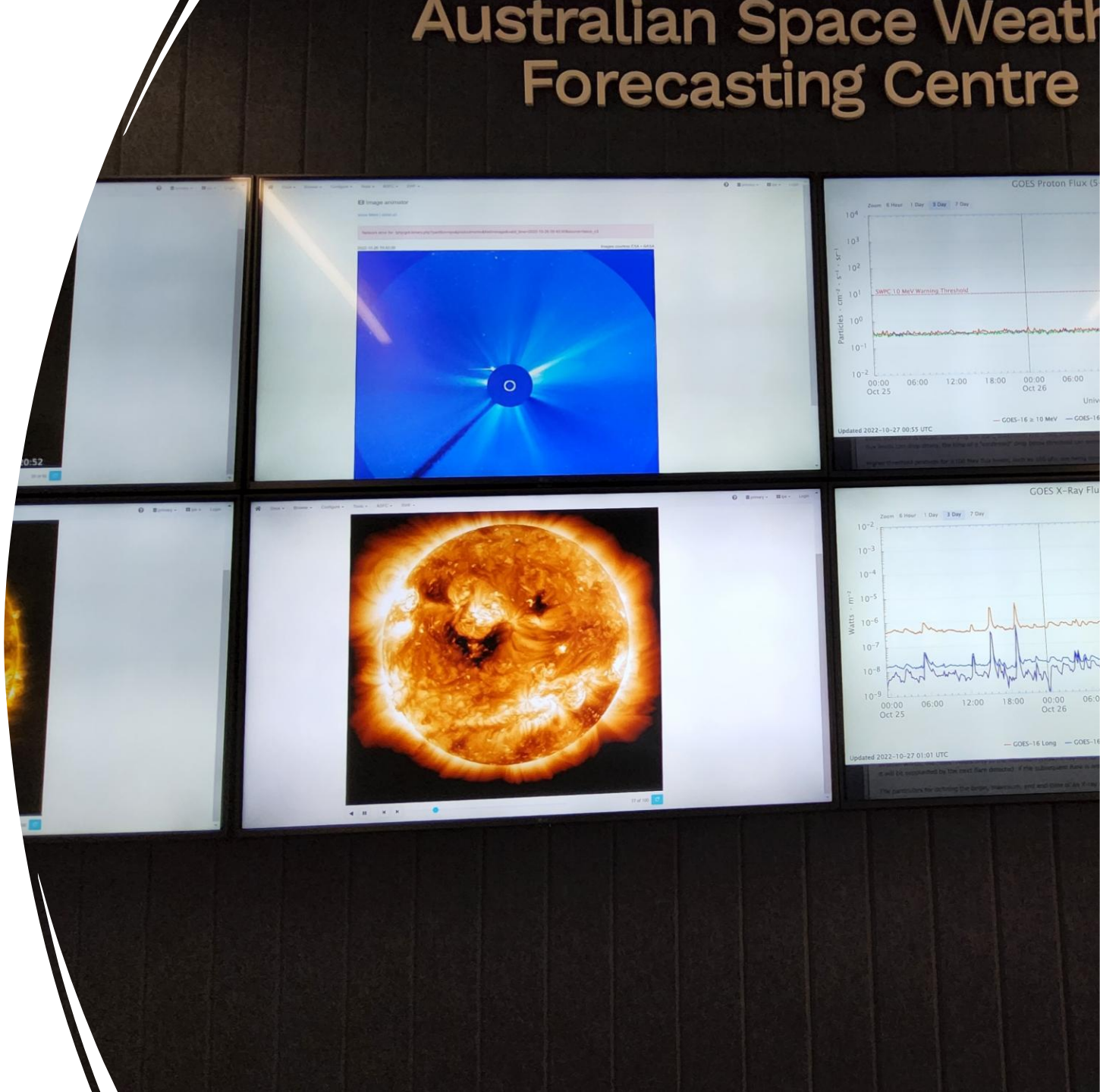
- Internet service could go down, which in turn would take out the ability of different systems to communicate with each other.
- High-frequency communication systems such as ground-to-air, shortwave and ship-to-shore radio would be disrupted.
- Satellites in orbit around Earth could be damaged by induced currents from the geomagnetic storm burning out their circuit boards. This would lead to long-term disruptions in satellite-based telephone, internet, radio and television.



Repeat of the 1859 Carrington Event?

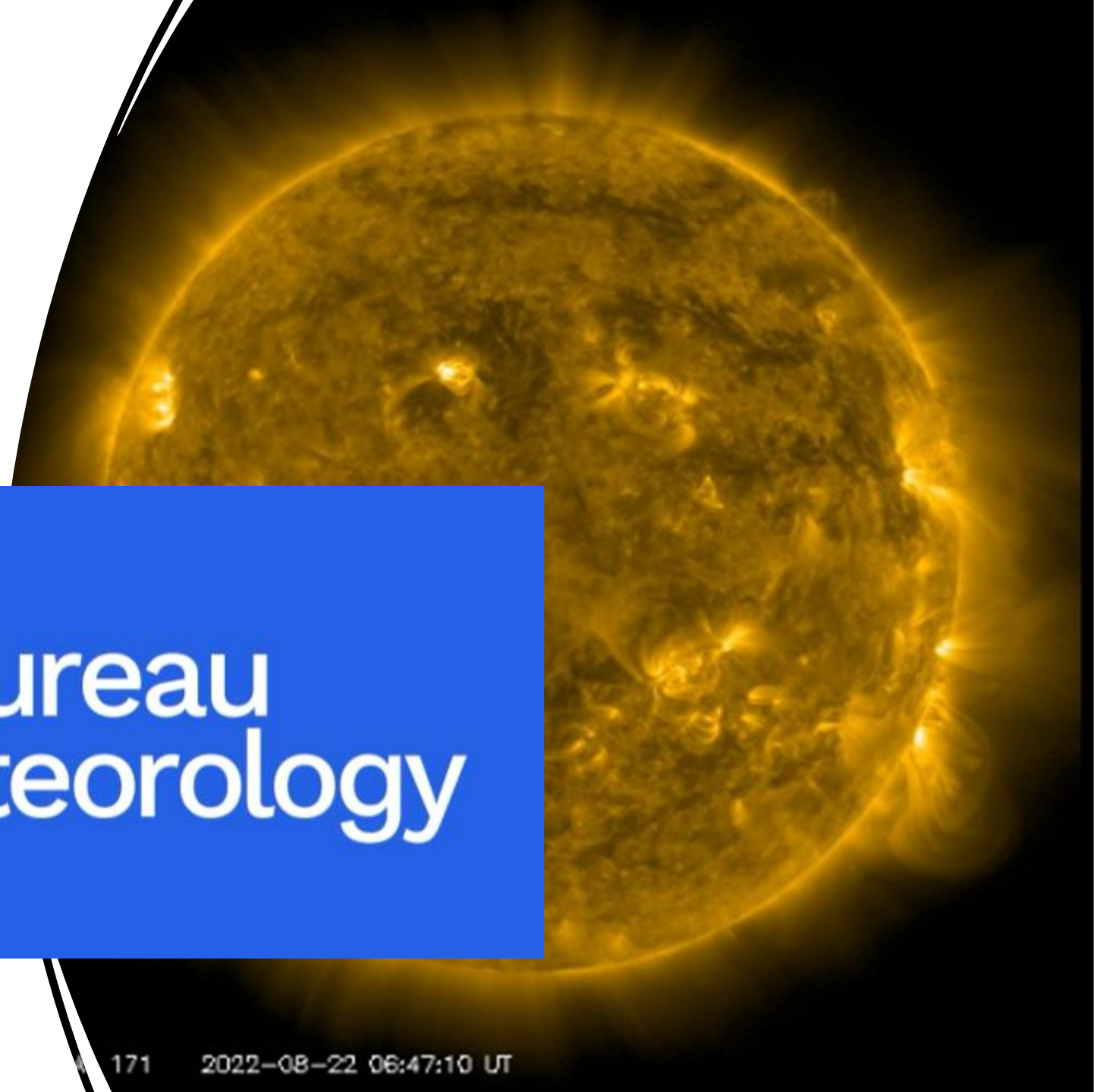
- Today, a geomagnetic storm of the same intensity as the Carrington Event would affect far more than telegraph wires and could be catastrophic.
- The storm would affect many of the electrical systems that people use every day
- With the ever-growing dependency on electricity and emerging technology, any disruption could lead to trillions of dollars of monetary loss and risk to life dependent on those systems.
- Also, as geomagnetic storms hit Earth, the increase in solar activity causes the atmosphere to expand outward. This expansion changes the density of the atmosphere where satellites are orbiting. Higher density atmosphere creates drag on a satellite, which slows it down. And if it isn't maneuverer to a higher orbit, it can fall back to Earth (or collided with other space objects).

SPACE WEATHER



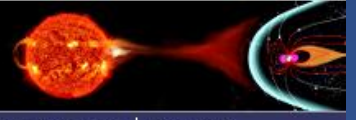
Space Weather

The Bureau of Meteorology



The Bureau of Meteorology

Australian Space Weather Forecasting Centre



FORECAST SOL: Moderate MAG: Normal ION: Normal

Space Weather Conditions

Updated every 5 minutes, last updated 25-Jul-2024 04:00:00Z

Past 24 hours	Current	25-Jul forecast	26-Jul forecast	27-Jul forecast
R1 Radio blackouts Minor	R0 Radio blackouts No	R1 – R2: 45% R3 – R5: 5%	R1 – R2: 45% R3 – R5: 5%	R1 – R2: 45% R3 – R5: 5%
S0 Radiation storms No	S0 Radiation storms No	S1 or greater:10%	S1 or greater:10%	S1 or greater:10%
G0 Geomagnetic storms No	G0 Geomagnetic storms No	G0 Geomagnetic storms No	G0 Geomagnetic storms No	G0 Geomagnetic storms No

For explanation of the R, S and G scales, and a description of risk and impact, see the Australian Space Weather Alert System. Colour scaling provides an indication of the alertness leve across each hazard. Green: Low to Medium, Yellow: High, Red: Very high. Unless otherwise indicated all times and dates are in UTC. Observation data from Bureau of Meteorology and NOAA/SWPC. R and G forecast by Bureau of Meteorology. S forecast by NOAA/SWPC.

Summary Forecast

Thursday 25 July — **last updated 24/2320 UT**

On UT day 25-Jul solar activity is expected to be R1-R2. The solar wind is expected to be light. G0 geomagnetic conditions are expected. S0 solar radiation storm conditions are expected, with a slight chance for S1. HF radio communication conditions are expected to be normal. Maximum usable frequencies are expected to be near predicted values to 20% enhanced.

Detailed forecast Summary Page Explanation

Site News

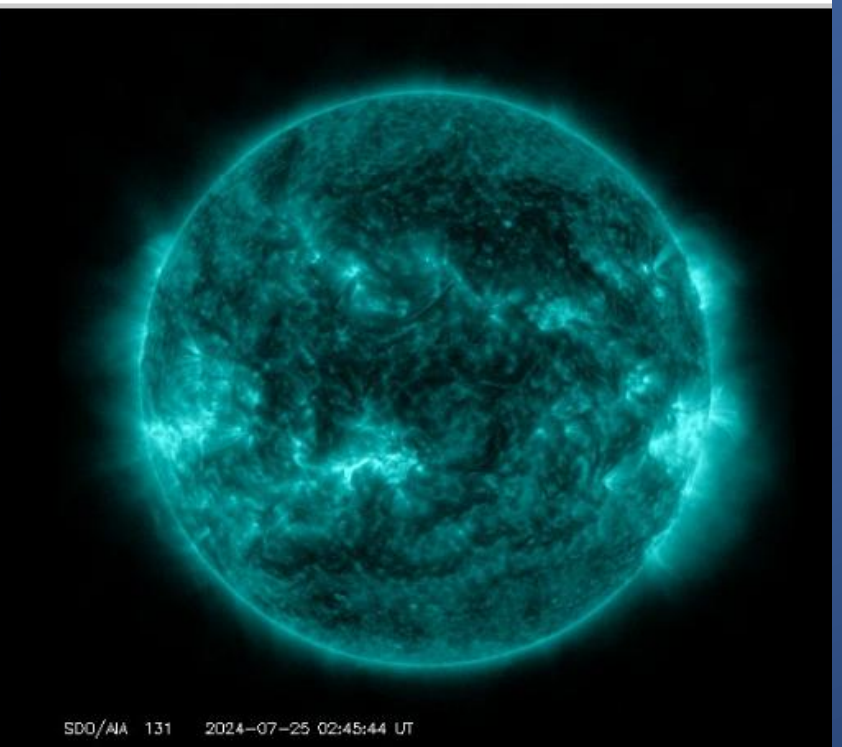
2024-06-11

On Wednesday 12 June 2024, between 1:00am and 7:00am (AEST), SWPC plans to perform a major network upgrade that will severely limit its operational capabilities and distribution of data to the ASWFC. Access to products and data on the SWPC website will also be impacted and at times will be severely limited to completely unavailable. This will have impacts on ASWFC products and services. Click for further det

2024-05-19

Space Weather systems are undergoing a planned upgrade. There may be intermittent outages from 12:00 pm (AEST) on 20 May 2024, for up to 24 hours, subject to any unforeseen

Site News in full



Conclusion

In critical communication design – our planning should include the possibility of “black swan events”.

What alternative solutions to providing communications if we cannot rely on our standard toolbox.

How will society react if the loss of technologies that we have become dependent on?

How will first responders react?

Conclusion

- Remember the risk cannot be transferred. You will always own the risk, and as the owner of the risk must play a key part in ensuring that potential threats are identified, understood and mitigated.

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