

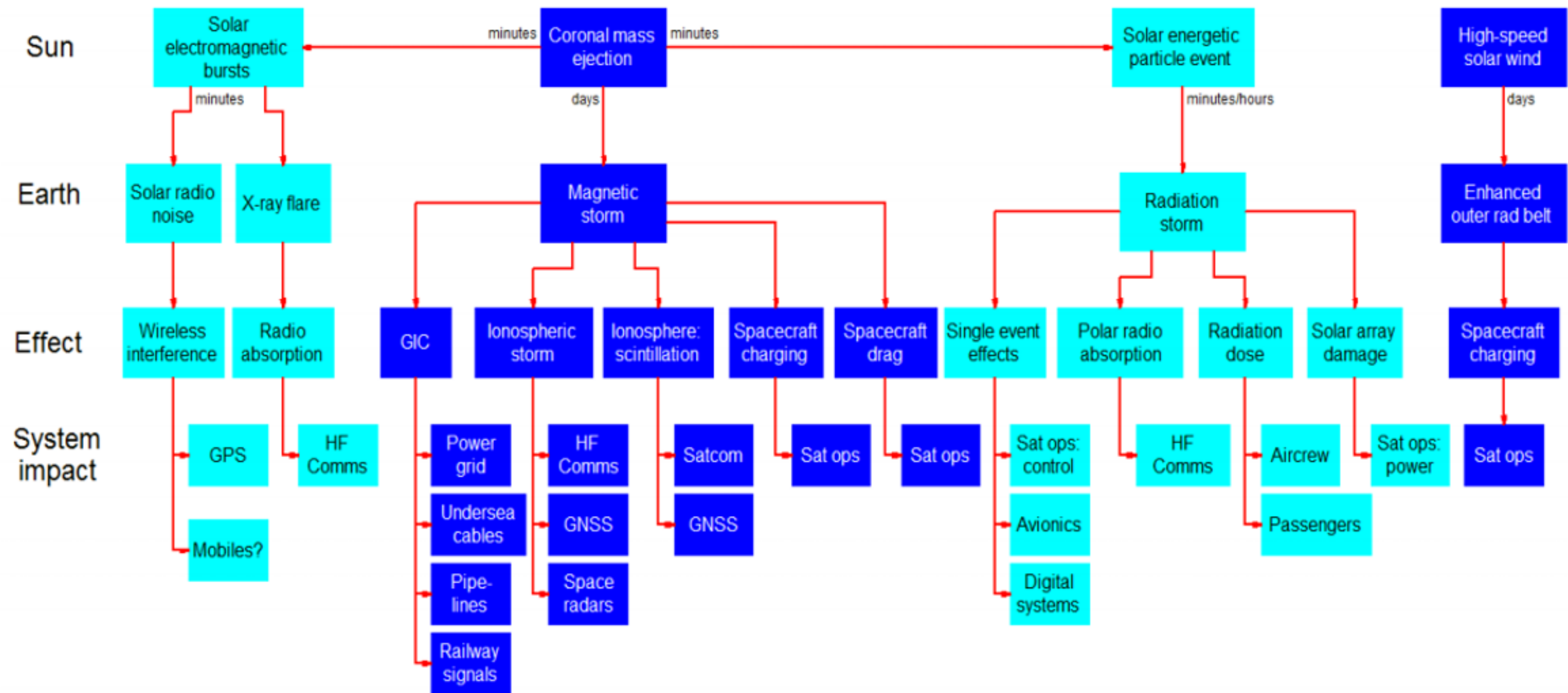
Disturbed Space weather

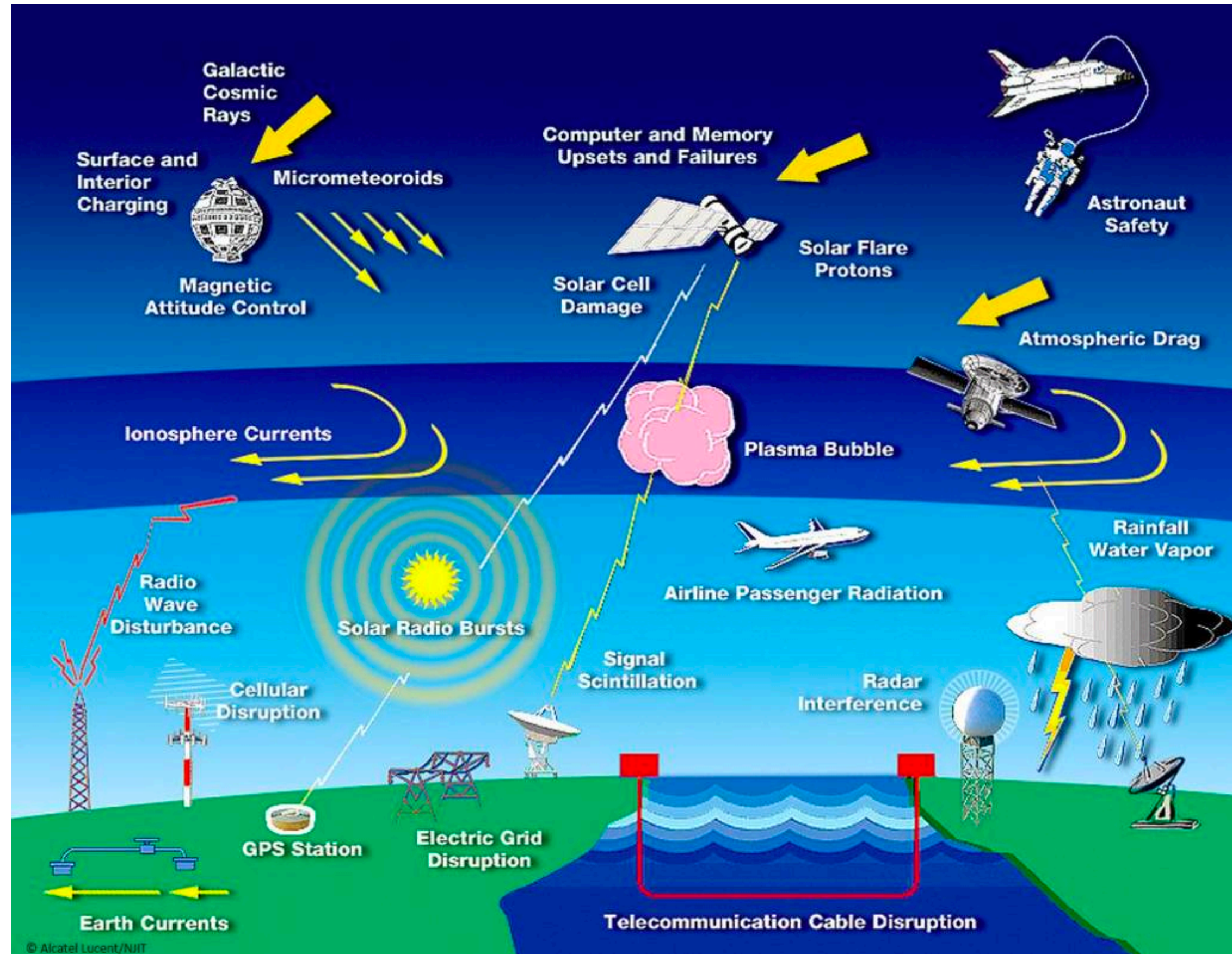
Causes	Solar flares	Proton events	Coronal Mass Ejections	Coronal Holes	
	Arrival	Immediately (8 min)	15 min to a few hours	20 to 72+ hours	2 to 4 days
	NOAA scales	R1 (minor) => R5 (extreme) <i>R = Radio Blackout</i>	S1 (minor) => S5 (extreme) <i>S = Solar Radiation Storm</i>	G1 (minor) => G5 (extreme) <i>G = Geomagnetic Storm</i>	
	Parameter	M1 => \geq X20	Pfu (>10MeV): 10 => 10 ⁵	Kp = 5 => Kp = 9	
	Duration	Minutes to hours	Hours to days	Days	
	Protection	Earth's atmosphere	Earth's magnetic field	Earth's magnetic field	

Effects	Radio communications <i>(SID, short wave fadeout)</i>	Satellites <i>(SEE, solar arrays, ageing, star trackers)</i>	Satellites <i>(Orientation, drag, charging)</i>	
	Radar interference	Astronauts & Airplanes <i>(Radiation Dose)</i>	Aurora	
	Navigation & Airplanes <i>(GPS, radar)</i>	Communication/Navigation	Communication/Navigation	
		Ground Level Enhancement	Electrical Currents (GIC) <i>(Long conductors, power grids, pipelines)</i>	

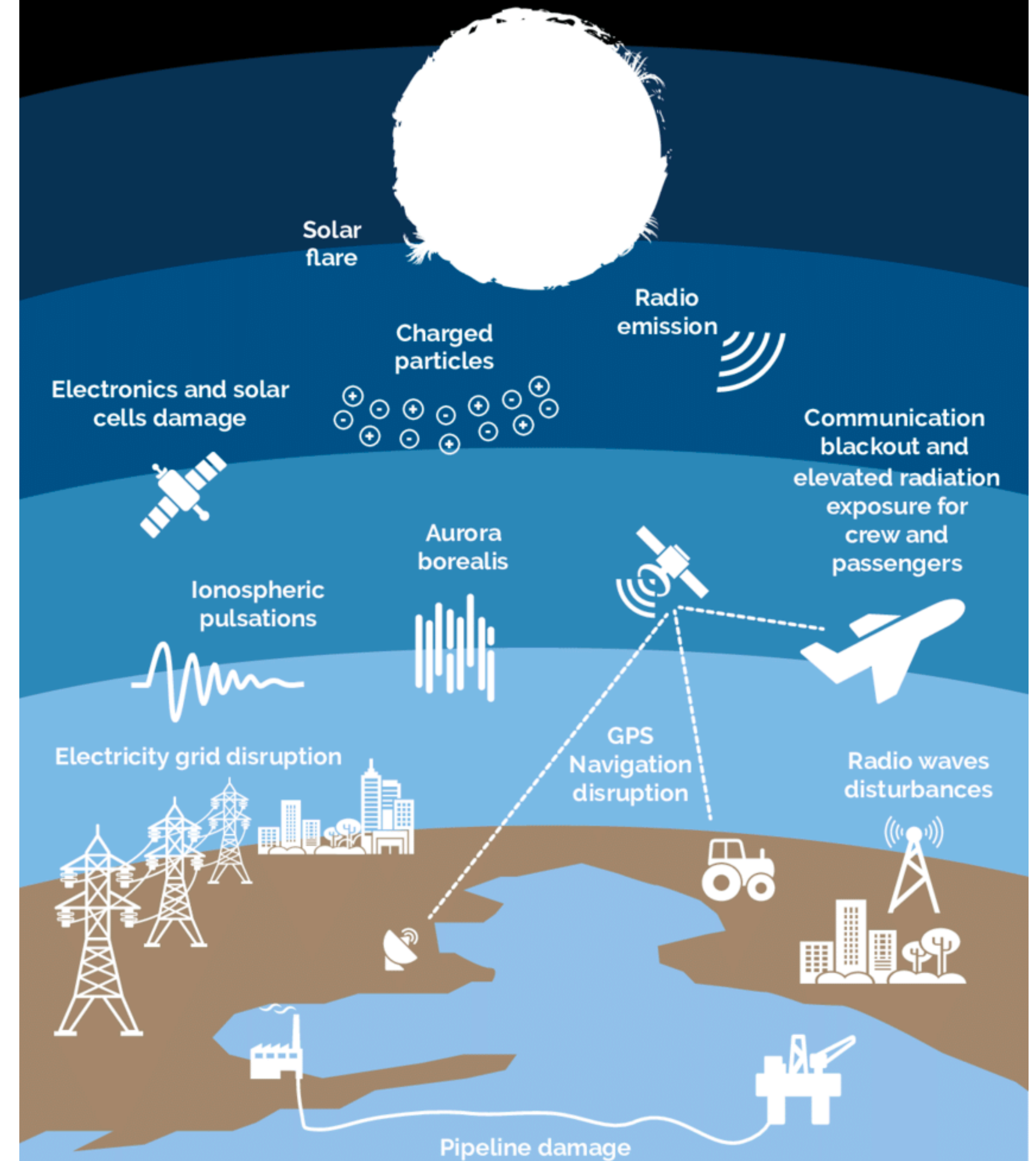
Storm Type	Travel time	Physical Impact	Technological Impact
Geo-magnetic	18-96h	<ul style="list-style-type: none"> · Geomagnetic induced currents · increased ionisation in ionosphere · heating in the thermosphere 	<ul style="list-style-type: none"> · Power grid outages, etc · GNSS, HF comms · Satellite and other hardware damage (eg surface charging) · Satellite orbits (drag, collision risk) · HF comms
Charged particles	10mins – 1 day	<ul style="list-style-type: none"> · increased radiation levels · damage to sensitive electronics increased · ionisation in ionosphere 	<ul style="list-style-type: none"> · Radiation health hazard (astronauts, aircrew) · Satellite heating and instrument noise, avionics, digital chips · as above - HF comms out for up to few days in polar regions
Solar flares	8mins	<ul style="list-style-type: none"> · HF radio signal interference · heating in the thermosphere 	<ul style="list-style-type: none"> · HF comms (~mins-hrs, sunlit side) · As above

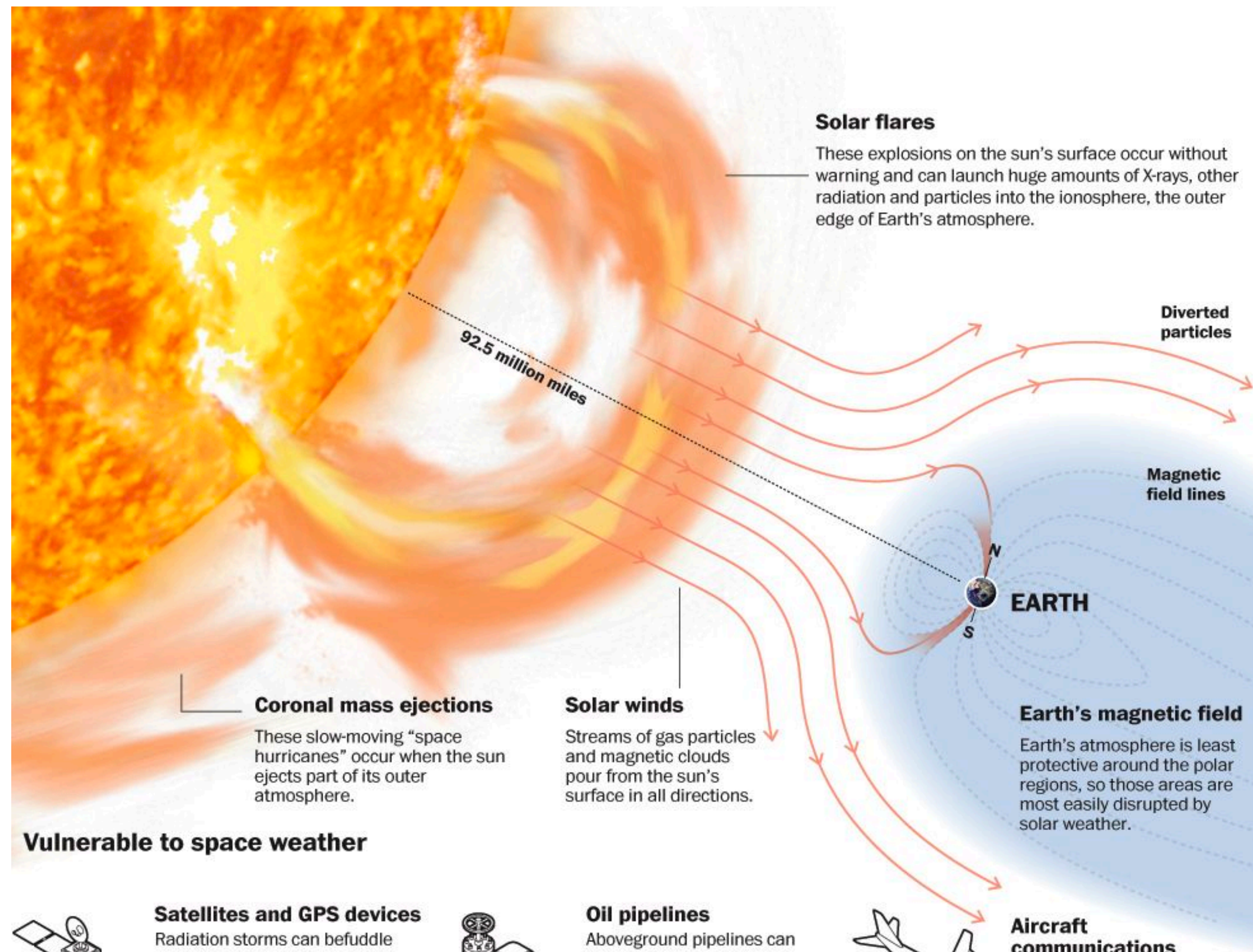
ANNEX D: Solar phenomena and their impacts



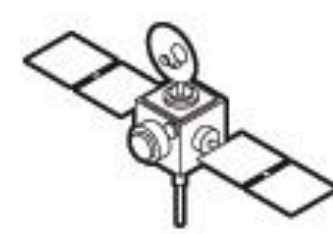


Potential Impacts of a Solar Storm on Earth





Vulnerable to space weather



Satellites and GPS devices

Radiation storms can befuddle satellites, delaying or garbling radio waves and mucking up sensitive electronic controls.



Oil pipelines

Aboveground pipelines can conduct stray currents and become corroded. Alaska's lines are vulnerable because they're so near the North Pole.



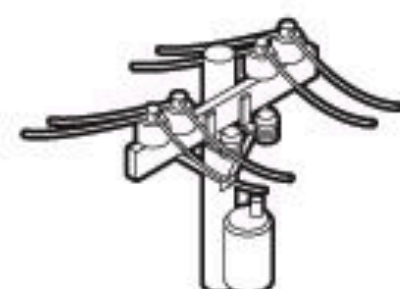
Aircraft communications

Transmissions that depend on low-frequency radio waves become unreliable, especially near the North Pole.



International space station

No humans are closer — therefore more vulnerable — to space radiation than residents of the space station.



Power grid

Power lines can conduct currents that develop in the ionosphere. The grid is so interconnected that a few blown transformers can cripple a large area.



Water supply

Because water processing and distribution depend so heavily on electricity, a major loss of power would affect water delivery within days.