



Extreme Space Weather Events and NATO Operations

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Outline of the Talk

- Definition an Extreme Space Weather Event
- Solar-Terrestrial Weather Phenomena
- Extreme SWx Events by Severity
- Semantic Ambiguity in the Definition
- Relevance of ESWxWs for NATO Operations
- SWx Monitoring in the NATO Framework
- Characteristics of SWx Information for NATO Operations

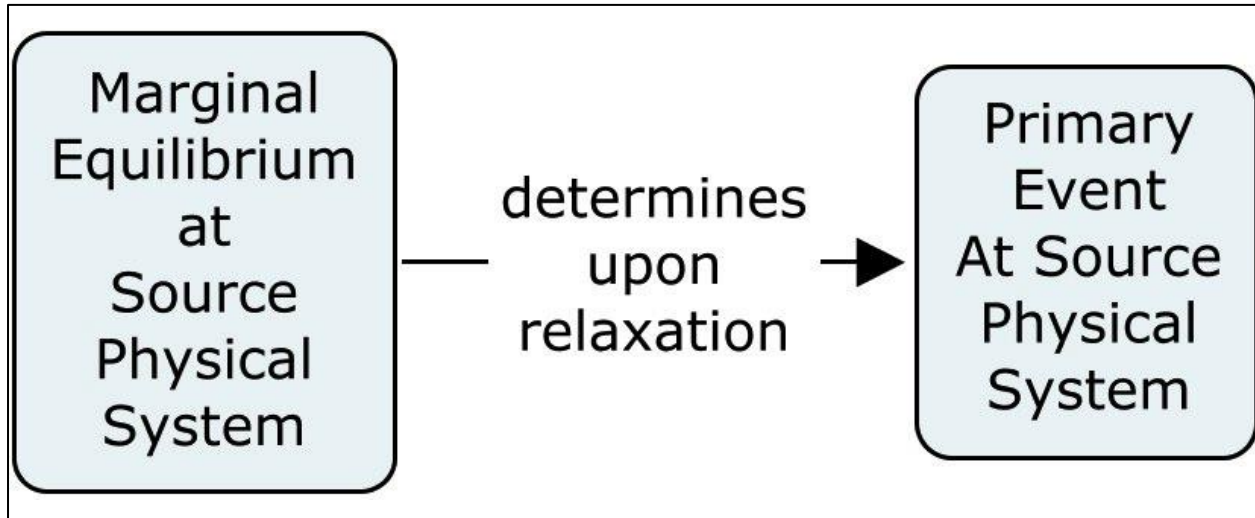
Definition of an Extreme Space Weather Event

- Should be based on:
 - ① A correct semantics
 - ② The energetics of the events' cascade
 - ③ The severity of the impacts
- Should be standardised

Solar-Terrestrial Weather Phenomena

- ① Solar Weather Events (e.g. Solar Flares)
- ② Interplanetary Weather Events (e.g. CMEs)
- ③ Geospace Weather Events (e.g. CME-MSPH)
- ④ Magnetospheric Weather Events (e.g. GM Storm)
- ⑤ Ionospheric Weather Events (e.g. TEC variations)
- ⑥ Geospheric Weather Events (e.g. GICs)

Solar Weather Event



Unstable Magnetic Topology in Solar Active Region

- Sunspot area
- Magnetic topology
- Magnetic helicity

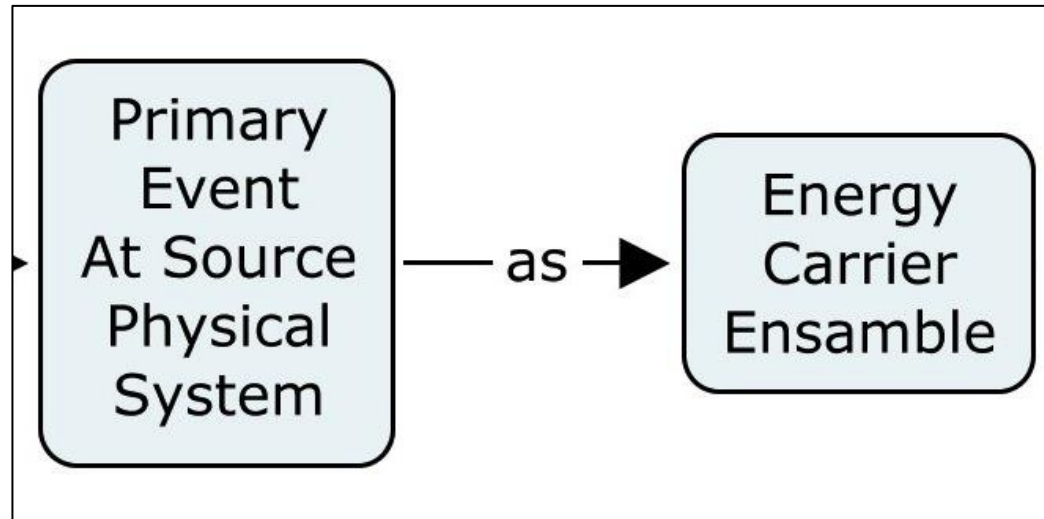
Magnetic Reconnection

- Parker
- Pile-up
- Stochastic

Solar Flare

- SXR peak
- SXR lightcurve

Interplanetary Weather Event

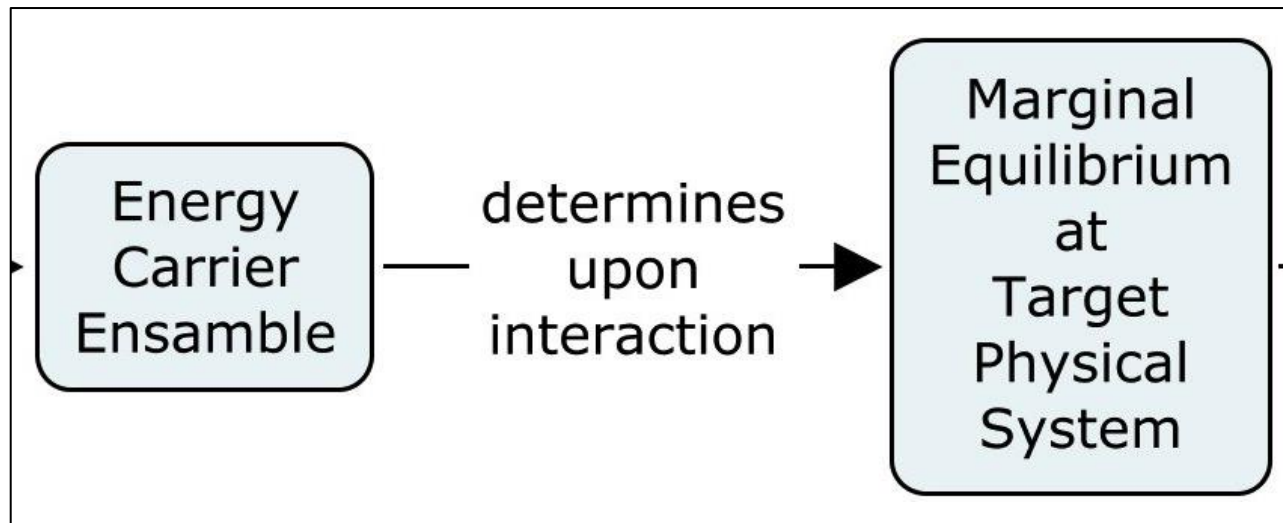


Solar
Flare

Coronal
Mass
Ejection

- Mass
- Dynamics
- Geometry

Geospace Weather Event



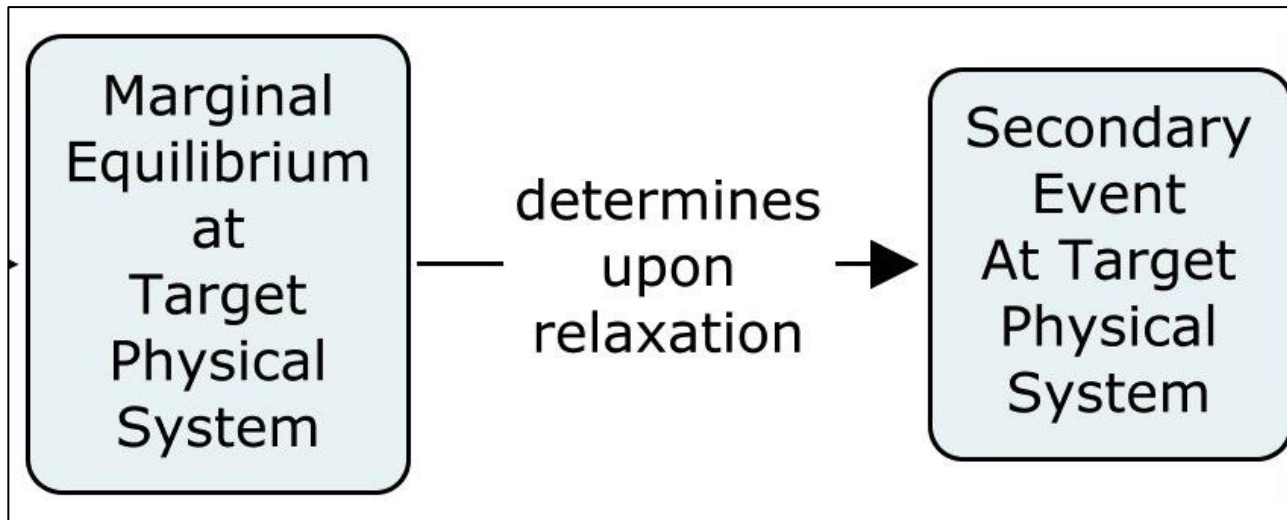
Coronal
Mass
Ejection

Energy
Transfer

Unstable
Magnetospheric
Configuration

- Ram Pressure
- Hemispheric Power
- Compression

Magnetospheric Weather Event



Unstable
Magnetospheric
Configuration

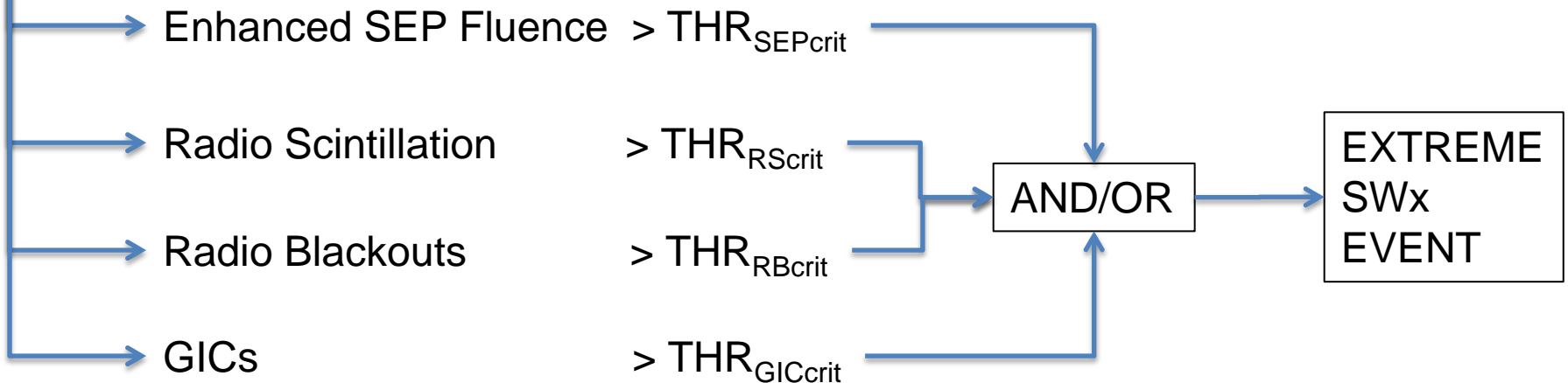
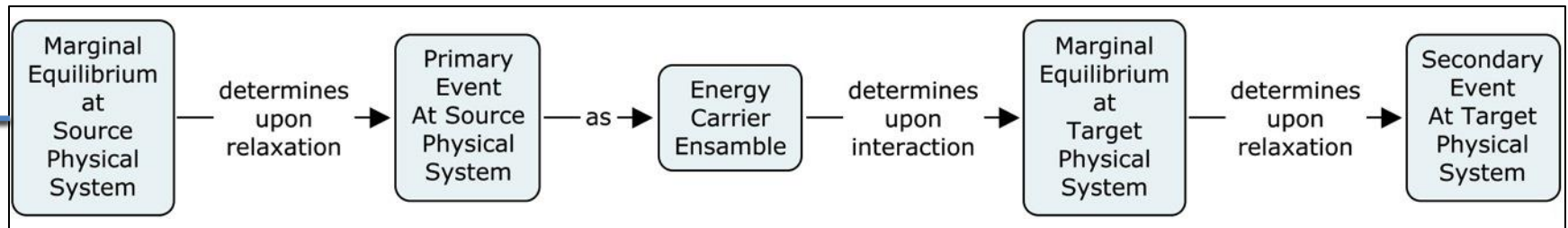
Geomagnetic
Storm

Geomagnetically
Induced
Current

- Kp, Dst
- Typology

- Intensity
- Geography

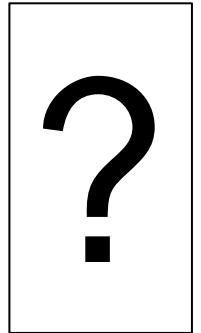
Extreme Space Weather Event by Impacts' Severity



Semantic Ambiguity to Be Solved

“Extreme Space Weather event” refers to:

- The Solar Flare
- The Coronal Mass Ejection
- The Geomagnetic Storm
- The Radio Blackout
- The GIC
- The relevant impacts on tech/bio systems
- The whole solar-terrestrial events’ cascade

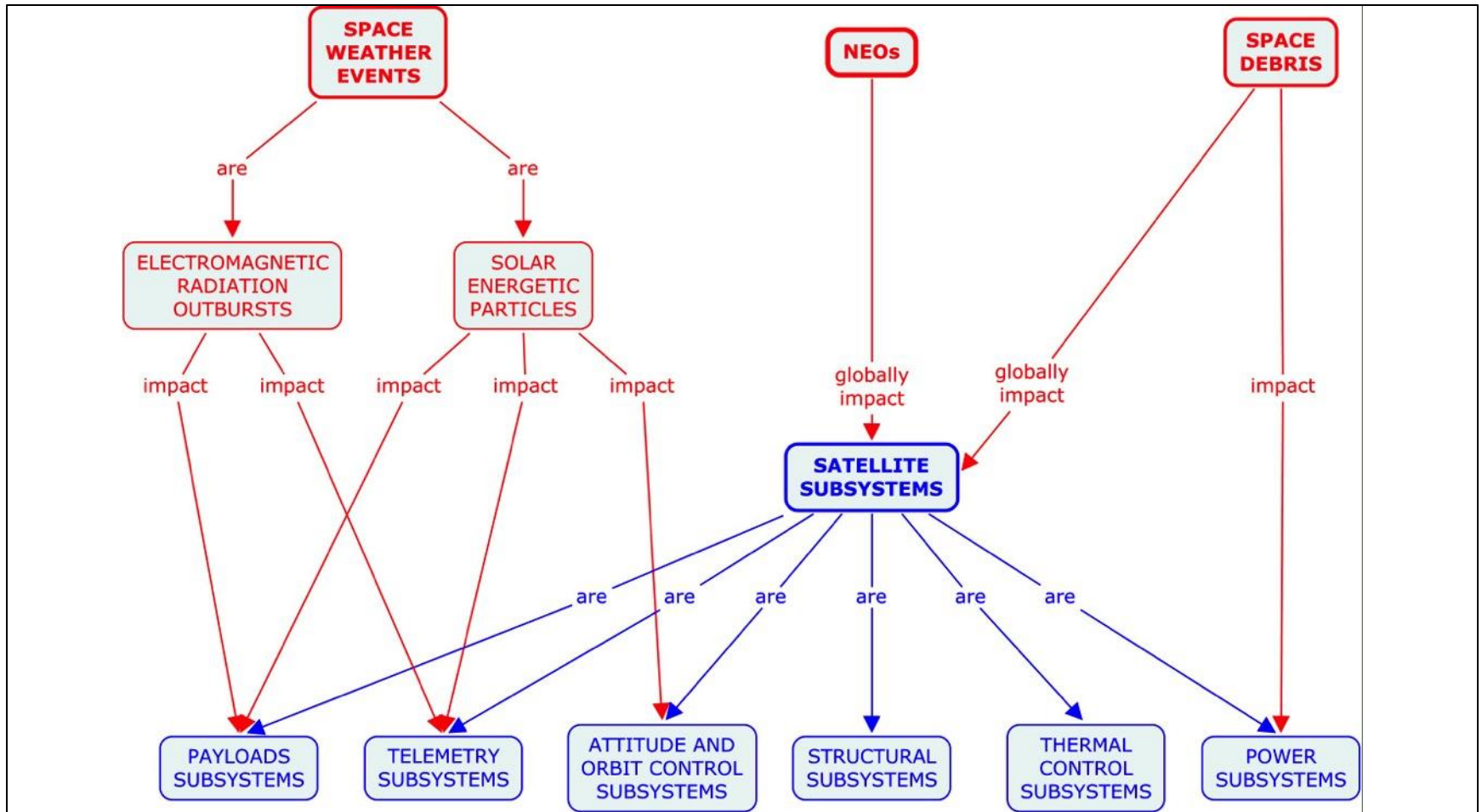


Relevance of ESWxEs for NATO Operations

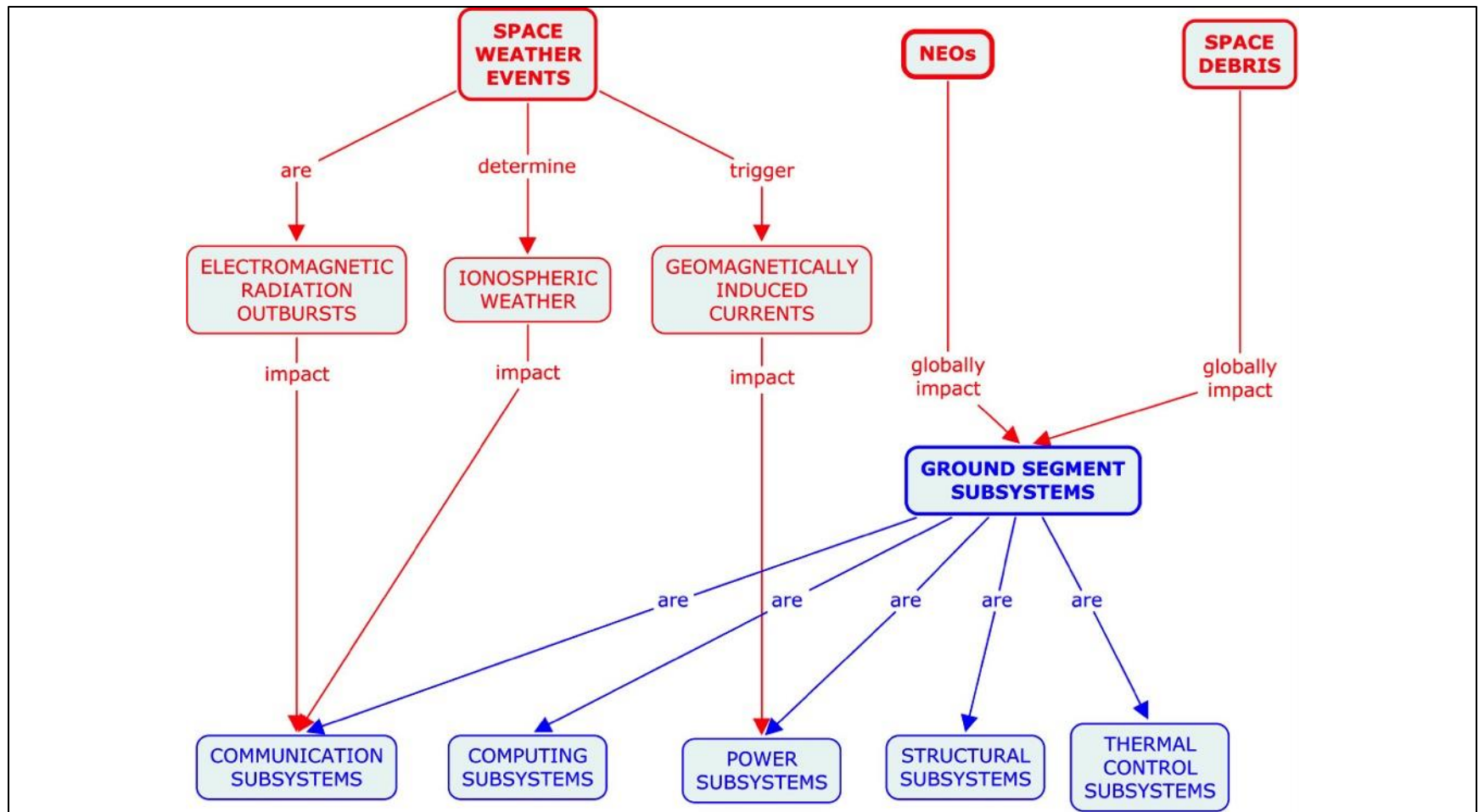
An Extreme Space Weather Event

- a. Can cause the unavailability of many services on which NATO operations rely on (e.g. COMs).
- b. Is a mission-critical factor, as it can completely jeopardise specific operations despite of the backup/mitigation techniques.
- c. Forecasts, nowcasts and prompt warnings are a must.

Satellite Segment Sub-Systems Affected by SWx Events



Ground-System Segment Sub-Systems Affected by SWx Events



SWx Monitoring and Warning for NATO Operations

- No ISES-like dedicated NATO network¹, as national facilities can be shared or not with Partners according to the principle of national sovereignty preservation.
- Monitoring and warnings are derived from:
 - a. Governmental/Institutional Public Services.
 - b. Non-Public Services (DoD-customised public services).
 - c. Classified Services (DoD-proprietary).

¹To my knowledge...

Characteristics of SWx Information for Successful Operations

- Target-dependent (operator, specialist, soldier)
- Prompt
- Essential
- Comprehensive
- Standard
- User Friendly
- On Global effects
- On Regional effects
- On Local effects
- With Alerts and Warnings w/nowcast and forecast

THANK YOU
FOR YOUR ATTENTION !