

# **Severe Space Weather: “Black Swan” or “Clear and Present Danger” (What decision makers need to know)**

**Presentation to  
Committee on Solar and Space Physics**

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**October 7, 2014**

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# Today's Objective

Develop a study approach to address the likelihood of an extreme solar event, which in turn will help decision makers know how much emphasis (and resources) should be put against planning for such an event

“How likely are such events? The answer of course depends on what you mean by ‘*event*’ and how severe you define ‘*extreme*’ to be. Nevertheless, our results overall suggest that the likelihood of another Carrington event occurring within the next decade is ~12%.”  
*“On the probability of occurrence of extreme space weather events”* --  
--Pete Riley, 23 FEB 2012, DOI: 10.1029/2011SW000734

# Black Swan

VS

## Clear and Present Danger

- **Black Swan:**
  - An event or occurrence that deviates beyond what is normally expected of a situation and that would be extremely difficult to predict
- **Clear and Present Danger:**
  - An imminent and plausible threat that unmistakably needs an immediate and substantial response

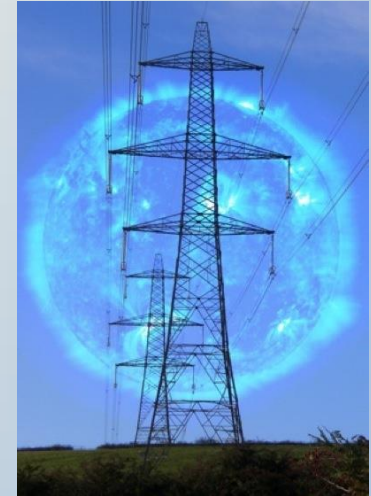


Image: K. Turnbull/J. Wild/ESA.

**A severe geomagnetic storm has the potential to produce large scale blackouts impacting large regions of the nation, lasting for months**

**If validated, a ~ten percent chance within the next ~ten years should elevate the threat of a severe geomagnetic storm to a higher level of urgency within the Nation's response planning.**

# Why Now?

- **Two recent events have captured the public's attention with regard to space weather, and they are somewhat related**
  - A July 2012 extreme CME missed Earth but was observed by STEREO A.
  - A publication, also in 2012, by Pete Riley, Predictive Science Inc., that indicates that the probability of an extreme event within the next ten years could be as high as twelve percent
- **The combination of the two, motivated by a July 23, 2014 NASA press release, led the Washington Post Editorial Board on August 9 to call for a national response to this threat**

**If the probability is as high as Riley suggests, then it moves extreme space weather out of the realm of “low frequency / high consequence” events, and into a realm where more urgent preparedness is needed.**

# Washington Post Editorial

August 9, 2014

...

The world can and should do more to prepare, adapting satellite systems, toughening electric grids and, above all, ensuring that scientists have the tools they need to anticipate space weather

...

Congress has a poor record of remembering to keep these sorts of important scientific tools in mind at funding time

For a variety of reasons — including the threat of severely inclement space weather — lawmakers must take a wider view

...

**Extreme space weather threatens to leave the U.S. in the dark**  
*-- The Post's View*

[http://www.washingtonpost.com/opinions/extreme-space-weather-threatens-to-leave-the-us-in-the-dark/2014/08/09/22782cd4-1c26-11e4-82f9-2cd6fa8da5c4\\_story.html](http://www.washingtonpost.com/opinions/extreme-space-weather-threatens-to-leave-the-us-in-the-dark/2014/08/09/22782cd4-1c26-11e4-82f9-2cd6fa8da5c4_story.html)

# A National Need:

## To Determine the Likelihood of a Severe Space Weather Event

- For the past few years, every conference, workshop, and report on the threat of space weather to the power grid has noted the need for a credible estimate of the likelihood of a “Carrington-type” event
- Riley’s findings suggest they may be significantly more likely than previously believed
- At first blush a rate of twelve percent within ten years seems too high, given our experience over the past few decades
- Assuming Poisson distribution and ignoring solar cycle effects:
  - It implies a 50-50 chance such an event would have occurred within the past 50 years, and  $\frac{3}{4}$  chance we would have had one or more in the past 100 years
- What have we observed in the recent past?
  - Certainly the 1859 storm, 155 years ago, qualified
  - A 1921 storm may have been extreme
  - There are other storms that may have come close to “extreme” but for one or more reasons did not cross the threshold (March 1989, for example)

# Snapshot of Prior Studies

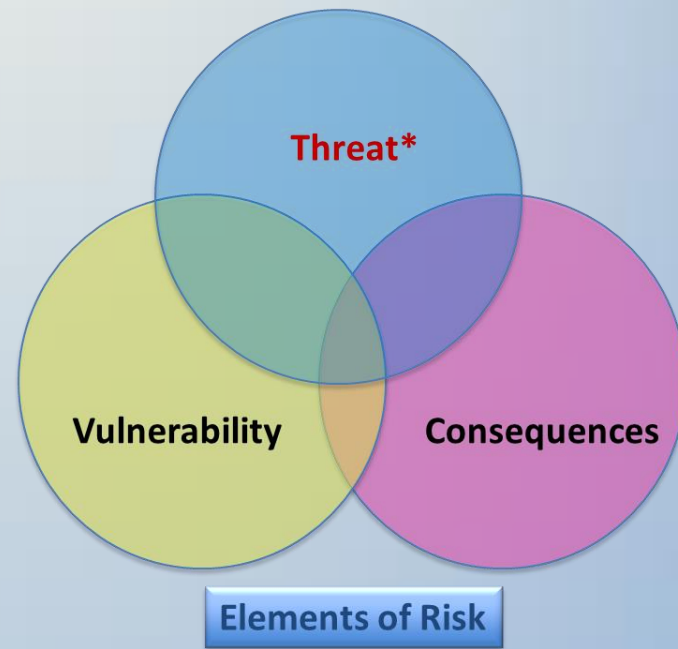
## (not a full bibliography)

- North American Electric Reliability Corporation (NERC) must establish a “worst case” design-to event that can be addressed by the power industry
  - NERC decided to focus on the one event for which they had reliable data: the March 1989 event
- NASA has had two workshops on “Extreme Events” in the past few years
  - The NASA workshops consider a wide range of metrics for “extreme”: in radiation levels and a variety of geomagnetic indices
- Insurance and re-insurance companies (for example, Lloyds of London) have had to address the issue directly
- Many of the studies have concluded that the data are not adequate for a quantitative assessment, or that the metrics for “extreme” are too diffuse: one storm may be extreme in one category but relatively minor in others
  - For example, a 2011 JASON study noted
    - “Statistical predictions of CME characteristics and of GIC are promising approaches”
    - “Solar research is progressing rapidly, and physics-based modeling is impressive, but we are not aware of rigorous comparisons of predictions with observations”

We have the opportunity to establish a study that gets to the heart of a key science-based question: what is the likelihood of a severe geomagnetic storm?

# Proposed NRC Committee Charge

- Establish an NRC Committee to review the probability of an extreme event
- The committee charge should be very focused:
  - Address Riley's conclusions, specifically
  - Is the likelihood of an extreme space weather event, with Dst approaching -1000 nT, close to ten percent within ten years?
- The committee should be staffed by experts in space weather and by outside experts familiar with statistical analysis of extreme events
- To enhance the credibility of the findings, no one with a vested interest in the outcome should be on the committee, but the committee should invite presentations from a broad cross-section of perspectives



\*The focus of the proposed study

An expert committee review will ensure that the topic is addressed from an unbiased and science-based point of view. It would also help articulate the complexity of the issue and identify needs for further study, all in a timely manner.



# Study Elements: a Narrow Focus

- The emphasis of the study should be on a statistical analysis of the frequency and intensity of large Geomagnetic Storms
- The study should have an introduction that provides the societal context of the importance of the study, understandable by decision makers
  - Address qualitatively what Dst is and how it relates to other metrics
  - Provide the operational context of why extreme space weather is important to society and how Dst relates to observable impacts such as Ground Induced Currents (GIC)
  - Finally, provide appropriate caveats discussing how Dst is a global measure and may not reflect local impacts
- However, the societal aspects of the study should not detract from the essential assessment of the limited charge to the committee
  - Detailed analysis of vulnerability and consequences should be left to a follow-on, more broadly staffed, study

**Broadening the charge to quantify other metrics would dilute the committee focus and would not meet the immediate national needs.**

# Conclusion

- **There are many approaches for clarifying the probability of an extreme space weather event, but few have the credibility of an NRC-led effort**
- **Riley's results are already influencing the political discussion**
- **An expert committee review will ensure that the topic is addressed from an unbiased and science-based point of view**
- **An expert committee review will also help articulate the complexity of the issue and identify areas for further study, all in a timely manner**