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# Status report of expert group on Space Weather

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## Outline of the presentation

1)Scope of expert group on space weather
2)Draft of the outline of the expert group repot
3)Identification of risks
4)Space weather monitoring
5)Space weather forefast tools
6)Mitigation of space weather effect

# Scope of the **Expert Group** (after ToR)

i) Collection, sharing and dissemination of data, model and forecast tool

ii) Capabilities to provide a comprehensive and sustainable network of sources of key data in real time or near-real time

iii) Open sharing of established practices and guidelines to mitigate the impact of space weather phenomena on operational systems

iv) Coordination among State on ground-based and space-based space weather observations in order to safeguard space activities.

# Draft of the outline of the expert group repot

1) Identification of Risks

2) Current practice and procedures
   - Observations
   - Models
   - Tools of Space weather prediction
   - Engineering approach to mitigate space environment effects

3) Capabilities to provide a comprehensive network to support space weather services

4) Recommendation on Coordination among States on space weather observations to safeguards space activities

# Time line (after Working Document)

| Year | 2012 | | | 2013 | | | 2014 | |
|---|---|---|---|---|---|---|---|---|
| Month | 2 | 6 | 10 | 2 | 6 | 10 | 2 | 6 |
| Space Weather Expert Group Meeting | △ | △ | △ | △ | △ | △ | △ | △ |
| Expert Group Repot | Out Line | 1-st draft | 2-nd draft | Final Draft | Submission | | | |
| Guide Line Paper | | | | Out Line | 1-st draft | 2-nd draft | Final Draft | Submission |

# Identification of risks (1/3)

| | Item | Influence and concern |
|---|---|---|
| 1 | Level and Trend of Solar Activity | General space environment risk evaluation. |
| 2 | Solar X-ray Radiation | Solar X-ray radiation is the widely used indicator for solar activity level and flare and associating disturbance harmful for space systems. |
| 3 | Solar High Energy Particle | Onboard computer malfunction due to upset of semiconductor devices, deterioration of SAP, electric devises, optical sensor etc… |
| 4 | Solar Flare and CME | Solar flares and associating CME are a major source of space environment disturbances. Generally, long duration and strong flares are thought to be important for risk evaluation on satellite operation sources of geomagnetic storms |
| 5 | Coronal Holes | Coronal holes are a major source of high speed solar wind, which produces geomagnetic storm. |

# Identification of risks (2/3)

| | Item | Influence and concern |
|---|---|---|
| 6 | Galactic Cosmic Rays | Onboard computer malfunction due to upset of semiconductor etc… |
| 7 | Solar wind plasma | Geomagnetic storm and Sub-storm caused by high speed wind stream are the potential causes of satellite malfunction. |
| 8 | K-index of geomagnetic field | General space environment risk evaluation. |
| 9 | Dst-index of geomagnetic field | General space environment risk evaluation. |
| 10 | Low energy electrons at GEO | KeV electron is considered major driver of satellite surface charging and following discharging. The surface charging and discharging is one of the major cause of GOE satellite malfunction. |
| 11 | High energy electrons at GEO | High energy (>MeV) electron is considered a major driver of satellite charging and following discharging including component and harness inside spacecraft. The charging and discharging is one of the major cause of GOE satellite malfunction. |

# Identification of risks (3/3)

| | Item | Influence and concern |
|---|---|---|
| 12 | Low energy electrons at LEO | KeV electron is considered major driver of satellite surface charging and following discharging. The surface charging and discharging is one of the major causes of LEO satellite malfunction. |
| 13 | High energy protons at SAA | Onboard computer malfunction due to upset of semiconductor devices, deterioration of SAP, electric devises, optical sensor etc… |
| 14 | Solar EUV proxy index | The proxy called f10.7 is used as solar EUV proxy parameter to deduce satellite drag on satellite orbital analysis. Abrupt increase of the proxy may cause severe trouble due to drastic changes of satellite drag. |
| 15 | Auroral Electro jet index | The AE is used to atmospheric density model, which leads to satellite drag on satellite orbital analysis. Abrupt increase of AE may cause severe trouble due to drastic change of satellite drag. |
| 16 | Ionospheric Disturbances | Operation of satellite at various altitude and ground communications by using radio waves are influenced by the ionospheric condition. |

# Space weather monitoring (1/2)

| | Item | Measurement in Japan (for example) |
|---|---|---|
| 1 | Level and Trend of Solar Activity | f10.7 radio index (NICT) |
| 2 | Solar X-ray Radiation | None |
| 3 | Solar High Energy Particle | In-situ measurement by satellite sensor (JAXA) |
| 4 | Solar Flare and CME | Ground-base observation (NICT) |
| 5 | Coronal Holes | Remote measurement by satellite sensor (JAXA) |
| 6 | Galactic Cosmic Rays | Measurement by satellite sensor (JAXA) |
| 7 | Solar wind plasma | Measurement by satellite sensor (JAXA) |
| 8 | K-index of geomagnetic field | Ground based magnetometer observation network and its real-time data circulation (SERC) |
| 9 | Dst-index of geomagnetic field | Ground based magnetometer observation network and its real-time data circulation (SERC) |
| 10 | Low energy electrons at GEO | None |

# Space weather monitoring (2/2)

| | Item | Measurement in Japan (for example) |
|---|---|---|
| 11 | High energy electrons at GEO | In-situ measurement by satellite sensor (JAXA) |
| 12 | Low energy electrons at LEO | None |
| 13 | High energy protons at SAA | In-situ measurement by satellite sensor (JAXA) |
| 14 | Solar EUV proxy index | None |
| 15 | Auroral Electro jet index | Ground based magnetometer observation network and its real-time data circulation (SERC) |
| 16 | Ionospheric Disturbances | Ground based magnetometer observation network and its real-time data circulation (SERC) |

# Space weather forecast tools

| | Item | Forecast |
|---|---|---|
| 1 | Sunspot | |
| 2 | Coronal hoes | |
| 3 | Flare/CME | *ISES/Flare forecast |
| 4 | Solar proton | *ISES/Solar proton forecast |
| 5 | Solar wind | Solar wind models |
| 6 | Geomagnetic field disturbance (Dst) | *ISES/Storm forecast |
| 7 | Geomagnetic field disturbance (AE) | *ISES/Substorm forecast |
| 8 | Radiation belt | Radiation belt models |
| 9 | Aurora | Aororal oval prediction models |
| 10 | Ionosphere | Ionosphere models |
| 11 | Radio wave propagation | Disturbance models |

# Mitigation of space weather effect

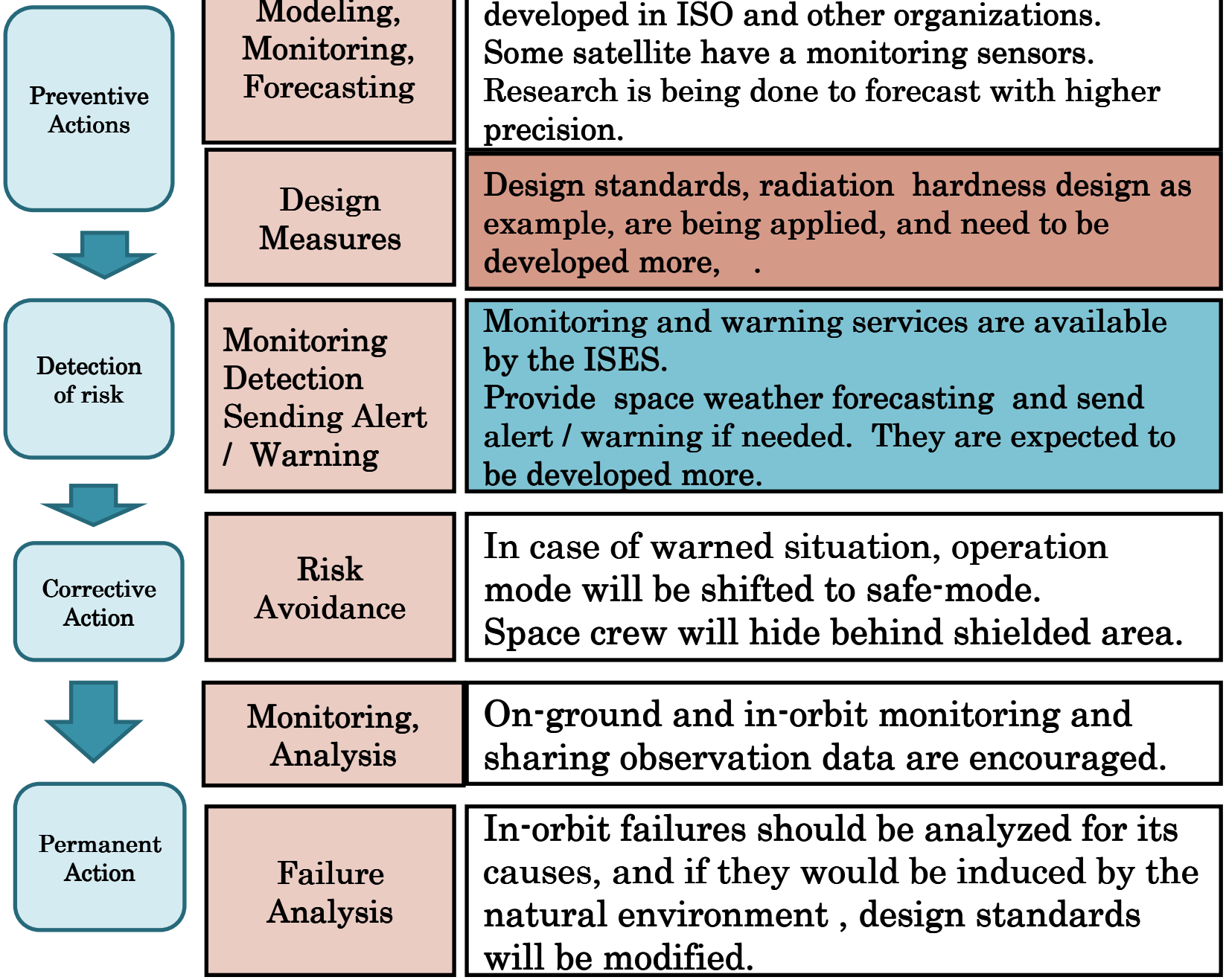
| | Item | Technical standards in Japan (for example) |
|---|---|---|
| 1 | Measures for mitigating charging | Technical satandard for satellite charging (JAXA) |
| 2 | Measures for avoiding single events | Technical satandard for satellite charging (JAXA) |
| 3 | Measures for mitigating total dose effect | Technical satandard for satellite charging (JAXA) |
| | | |
| | | |
| | | |

## Possible Conclusion for EG-C

The "International Space Warning Service" is expected to be continued and improved.

It is still need to make efforts for monitoring, modeling,, forecasting, warning, design measures, operational actions etc... against the risk from the space environment.

# Appendix


Preventive Actions
Modeling, Monitoring, Forecasting
Models of natural environment are being developed in ISO and other organizations. Some satellite have a monitoring sensors. Research is being done to forecast with higher precision.
Design Measures
Design standards, radiation hardness design as example, are being applied, and need to be developed more, .
Detection of risk
Monitoring Detection Sending Alert / Warning
Monitoring and warning services are available by the ISES. Provide space weather forecasting and send alert / warning if needed. They are expected to be developed more.
Corrective Action
Risk Avoidance
In case of warned situation, operation mode will be shifted to safe-mode. Space crew will hide behind shielded area.
Monitoring, Analysis
On-ground and in-orbit monitoring and sharing observation data are encouraged.
Permanent Action
Failure Analysis
In-orbit failures should be analyzed for its causes, and if they would be induced by the natural environment , design standards will be modified.