

UN/CROATIA WORKSHOP ON GNSS APPLICATIONS

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GNSS SPACE WEATHER RESILIENCE SCHEME

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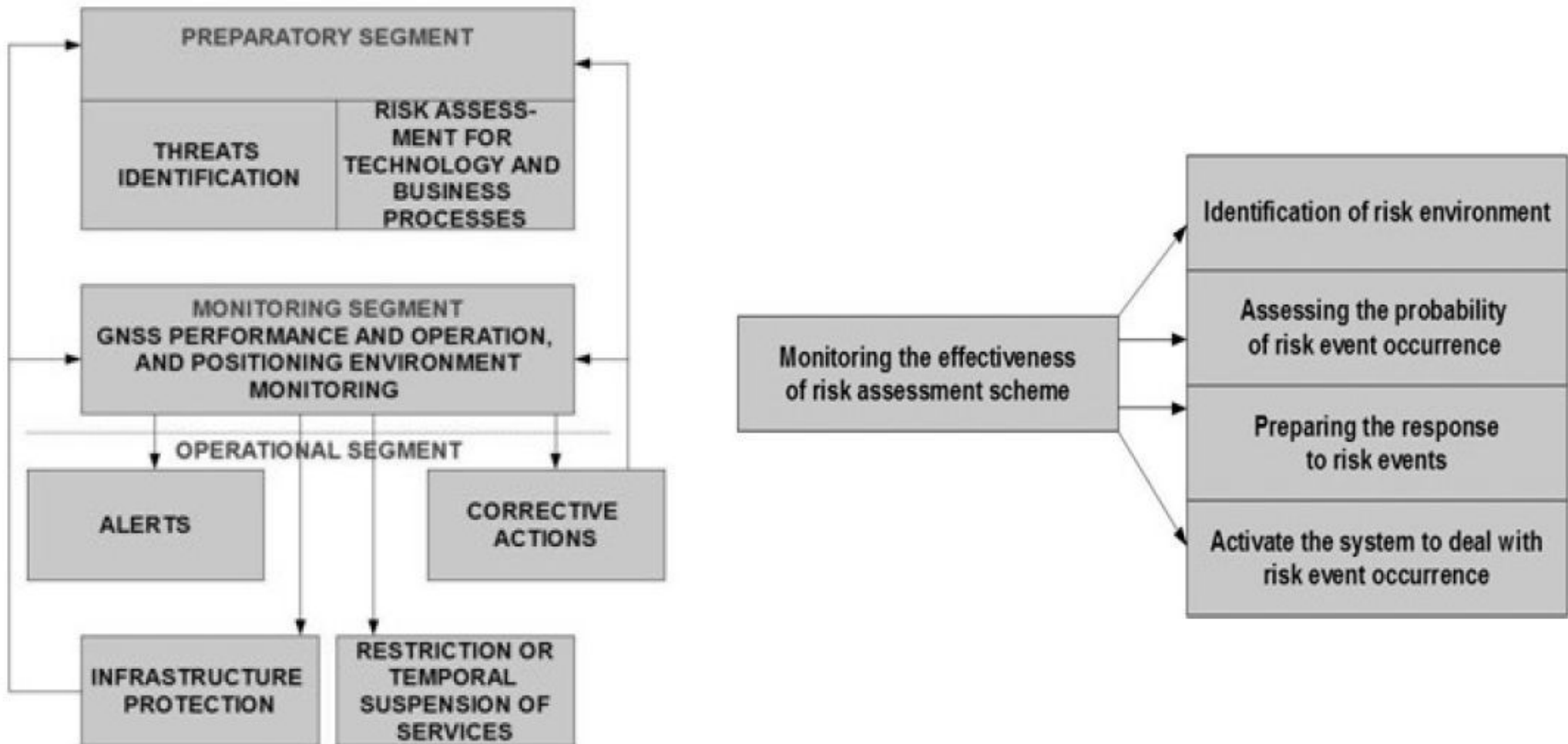
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- **Space weather effects on GNSS**
 - **Space weather effects on GNSS performance**
 - Accuracy deterioration
 - Reduced availability
 - Embedded corrective activities not tailored for the situation
 - **Space weather effects on GNSS operation**
 - Surface and deep dielectric charging
 - Single event upsets
 - Spacecraft drags
 - Accumulating dose effects
 - Photonic noise
 - Materials degradation

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General GNSS resilience scheme



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- **Technology advancements**
 - **Advanced error (ionospheric delay) correction models**
 - **Assisting and augmenting systems (DGPS, SBAAS/EGNOS/WAAS, A-GNSS)**
 - **Advanced utilisation of statistical signal processing and Bayesian modelling**
 - **Positioning sensor fusion**
 - **Combined positioning systems (i. e. GNSS + INS + map matching)**
 - **Utilisation of advanced GNSS receiver techniques and architectures (software-defined and cognitive radio, distributed architectures, cloud computing)**

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- **Risk assessment**
 - **End-users of GNSS and GNSS-based systems and services should perform a pre-assessment of the effects of space weather-initiated effects on their systems, services, operation and internal business processes**
 - **This pre-assessment is to be made by experienced GNSS and risk management specialists**

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- **Space weather monitoring**
 - **Continuous space weather and ionospheric dynamics monitoring**
 - **Complex and expensive systems vs fairly distributed network of low-cost sensors of ionospheric activity**

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- **Corrective actions**
 - **Putting in operation the alternative procedures to sustain business processes**
 - **Mitigation techniques to minimise the effects of influencing processes and variables**

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- **Space weather alerts and forecasts**
 - **Based on the analysis of GNSS and space weather data, and the risk assessment of the potential GNSS threats, operations and performance deterioration**
 - **Alerts to general public and targeted groups of GNSS users**
 - **Forecasts of probability of GNSS-related events**
 - **Already available: NOAA USA OMA (European Union), www.ionosphere.hr (Faculty of Maritime Studies in Rijeka, Croatia),**

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- **Division of responsibilities**
 - **GNSS operators – core system operation, global assistance and augmentation, global ionospheric and the other natural effects**
 - **National governments – GNSS signal and spectrum protection on national level, combating local jamming and spoofing, regulating service provision, space weather monitoring**

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- **Division of responsibilities**
 - **Service providers – proper usage of standardised equipment, combating user-initiated jamming, targeted GNSS performance deterioration alerts, service provision risk assessment**
 - **End users - responsible and honest use of GNSS-based systems and services**

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- Conclusion
- GNSS as a part of national infrastructure
- Growing number of technology- and socio-economic systems rely upon GNSS
- Space weather and ionospheric dynamics - the single major cause of GNSS performance deterioration and potential temporal outages
- Understanding of space weather and ionospheric effects on GNSS performance and operation-essential for building robust satellite systems and provision of seamless and high-quality GNSS-based services

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- Conclusion

New GNSS-related jobs to be created: space weather forecaster, GNSS performance specialist, GNSS space weather risk specialist, GNSS application developer, GNSS-specialised solicitor/lawyer, GNSS-based development strategist

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**THANK YOU FOR
YOUR ATTENTION !**

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