Earth Observation Exploitation and AI-Enabled Ground Segment: Roadmap

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Layout

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  - GS advancement and new technology trends
  - CSA AI Roadmap under study
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Context

- Recently, there has been an increase in countries need for Earth Observation (EO) missions' data. In order to exploit such data, Ground Segments (GS) which constitute the ground-based Information technology infrastructure (IT) are built specifically to accommodate each mission's needs. Those infrastructures are necessary to support the operation of satellites, including mission control, mission planning, automation, order acquisition, image production, data processing and data delivery.

Context

- The need for Earth Observation (EO) missions' data.
  - CSA SAR program
    - RCM Launched in 2019 as the most modern Canadian Space Utilisation program
    - Generation of daily high volume of data used by Government, Academia, Industry and Individuals,
    - The integration of other missions EO data
    - Multiple end user applications using different processing levels, different applications, etc.: Economic Development, Social well being, Climate change monitoring, Environment (Ice), Security, Agriculture, etc.

Context

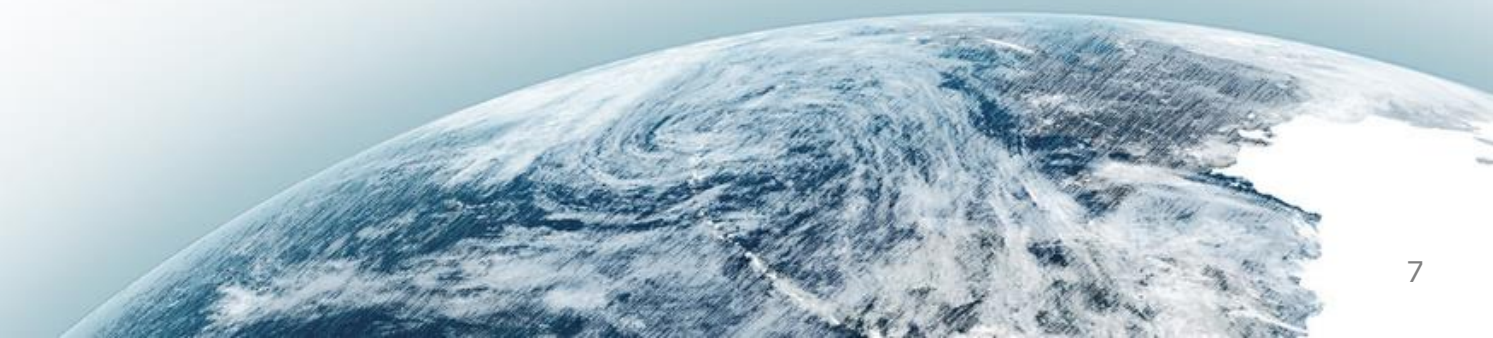
- Earth Observation Data exploitation
  - Key to furthering this innovation are the developments in ground segment architectures that support missions that will be capable of delivering high-quality Earth Observation data and be responsive to the evolving needs and demands of end-users.
    - Ground Segment innovations:
      - Full autonomy from acquisition, planning, FD to production
      - Image quality
      - Brining Applications to Data
      - *Reuse* of GS platforms and missions' sensors
      - Cyber security
      - Self-awareness, self-control, and self-improvement through learning and Machine-to-Machine connectivity

Context

- Mission based ground-based Information technology infrastructure (IT)
  - Exploitation can be supported through the scientific advancements in areas of virtualization, cloud computing, cyber security, and AI/ML

Driving Technologies:
Earth Observation (EO) Data Exploitation Systems (DES) for Space-Based Surveillance (SBS) design

- Virtual Missions:
  - A logical approach.
  - Agnostic to the space assets they are requesting data from.
  - Highly adaptable planning system based on multiple acquisition algorithms.
  - Highly efficient operation center.



Driving Technologies:

- Cloud Computing
  - Bring Applications to Data
  - By adopting the right cloud strategy, immense value can be extracted from data and efficient workflows designed around data compatibility and access protocols for various clients and users.
  - The improvement of EO systems through the definition, design and tested demonstration of a platform for mission planning, discovery, access, processing and exploitation of EO data.

Driving Technologies:

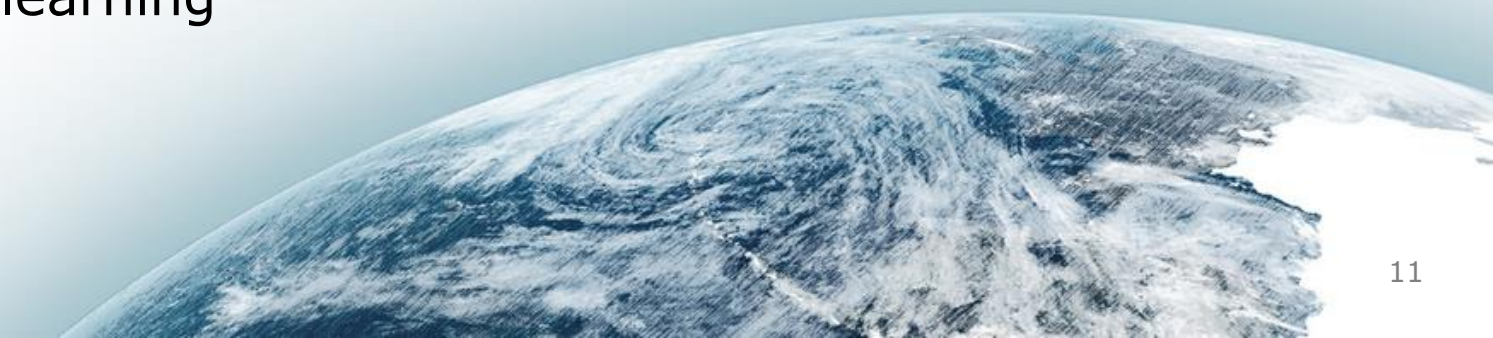
- Cyber security
  - Distributed General Ledger technologies such as block chain can be used to independently verify the integrity and provenance of the Earth Observation data sets.
  - AI/ML in Cyber security
  - Enhanced security features such as advanced perimeter firewalls, intrusion detection systems and data-at-rest encryption could be incorporated to fully comply with data integrity protocols.

Driving Technologies:

- AI/ML
  - GS Infrastructure monitoring
  - Flight Dynamics: detecting Space assets anomalies and GS failures trends
  - Cyber Security
  - Image processing and quality
  - Decision making
  - Training

Driving Technologies:

- Systems Engineering
- The world is on the footsteps of a time where the advances of technology supported by AI will force all stakeholders to re-examine their traditional methods for designing and engineering of all future intelligent and autonomous systems.
- Intelligent and autonomous systems would have the advantages of:
  - Self-awareness
  - Self-control
  - Self-improvement through learning
  - Self-sufficient

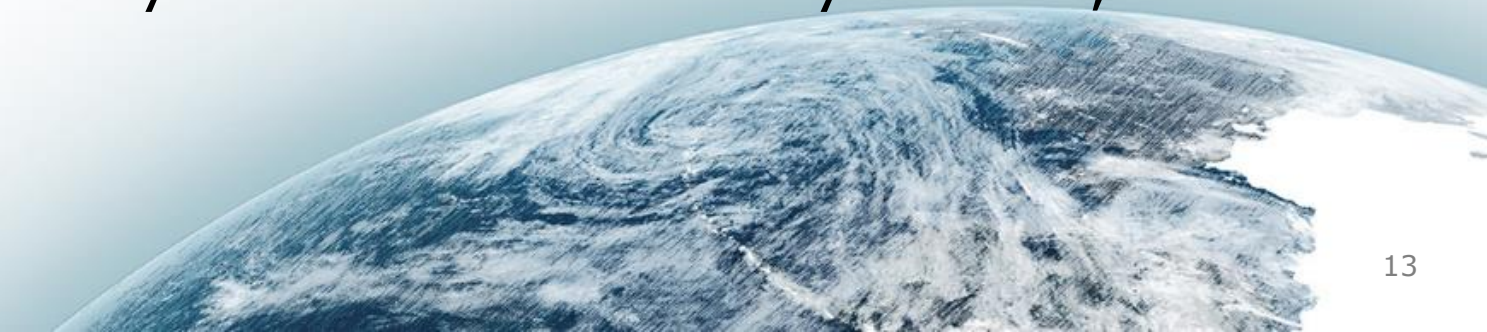


CSA Stepping towards Advanced Technologies: Planning

- **Autonomy and AI Strategy for the program**
  - Canada's Innovation and Skills Plan
- **Application Area Identification**
  - Training
  - Task Planning
  - Task Execution
  - Predictive Maintenance and Troubleshooting
  - Engineering
  - Situational Awareness
  - Data
  - Public Relations
- **Planning Section**
  - Level 1—An already existing product can be modified to achieve the purpose;
  - Level 2—Development of technology is required that would complement already existing products to achieve purpose;
  - Level 3—Development is required that may require significant effort.
- **Implementation Section**
  - Pre, during, and post project
  - Hardware can wait for software
  - Build up from low level autonomy (level 1 on the self-driving scale), to full autonomy

Conclusion

- In order to further innovation using Earth-Observation data, key evolutions must occur in ground-segment design.
- Automation has been used in an attempt to increase responsiveness to the EO data production chain, but still relies on oversight from humans.
- Foals for the ground-segment to be capable of self-awareness, self-control, and self-improvement through learning and Machine-to-Machine connectivity.
- Adaptations will also need to be made in the systems engineering process, especially in the case of safety-critical, low risk tolerant systems.



Canadian Space Agency

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