The Canadian Wildland Fire Monitoring Sensor (CWFMS) Mission Proposal

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Canadian Space Agency

2nd GWIS & GOFC-GOLD Fire IT Meeting
Nov 20th 2017, London UK
Fire Characterization Data

- Hotspot Locations
- Fire Radiative Power (FRP)
- Rate of Spread (ROS)
## Relevant Wavelengths
measured in the infrared and visible spectrum

<table>
<thead>
<tr>
<th>Spectral Band</th>
<th>(μm)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible – Near Infrared (VNIR)</td>
<td>0.5-0.6</td>
<td>• Cloud mapping</td>
</tr>
<tr>
<td></td>
<td>0.6-0.7</td>
<td>• Burned area mapping</td>
</tr>
<tr>
<td></td>
<td>0.8-0.9</td>
<td></td>
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<tr>
<td>Short-Wave Infrared (SWIR)</td>
<td>1.6-1.7</td>
<td>• To improve burned area mapping</td>
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<td>Mid-Wave Infrared (MWIR)</td>
<td>3.5-4.2</td>
<td>• High Temperature Event (HTE) detection</td>
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<tr>
<td>Long-Wave Infrared (LWIR)</td>
<td>10.4-12.3</td>
<td>• Surface temperature characterization</td>
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<td>• False detection (sun-glint) identification</td>
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<td></td>
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<td>• Bi-spectral methods for sub-pixel fire</td>
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<td></td>
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To obtain ENERGY
Measurements Needed by the Users

- Fire characterization data is needed:
  - Every 2 – 3 hours;
  - Of every point in Canada;
  - For fires as small as 15 m by 15 m;
  - Available within 30 min. after data acquisition.

Only possible from space
With a constellation of satellites
Affordable with low-cost satellites
Space Missions
With Fire Monitoring Capability

MODIS

VIIRS

AVHRR

SLSTR

FIREBIRD

GOES
CWFMS Comparison with Other Satellites
Revisit against Ground Sampling Distance (GSD)

- MODIS CONSTELLATION: AQUA; TERRA
- VIIRS CONSTELLATION: SUOMI NPP; JPSS-1
- SLSTR CONSTELLATION: SENTINEL-3A; SENTINEL-3B
- METOP CONSTELLATION: METOP-A; METOP-B
- POES CONSTELLATION: NOAA15; NOAA18; NOAA19
- FIREBIRD CONSTELLATION: TET-1; BIROS
- CWFMS CONSTELLATION: 9 SATELLITES, 3 ORBIT PLANES

Number of Canadian Passes (Per Day)

Ground Sampling Distance (m)
Limitations of Available Satellite Infrared Data

- Saturation issues;
- Insufficient temporal or spatial resolution;
- Data latency;
- Time of measurement in the day;
- Coverage of Canadian forests.
CWFMS Mission Feasibility Study (completed in 2016)

Leading the Users & Science Team

Users & Science Team

Space Industry Team

Canadian Space Agency

Leading the Industrial Team
A Canadian Solution: Uncooled Infrared Detector Technology

- A microbolometer is a thermal detector. Infrared radiation strikes the detector material, heating it, and thus changing its electrical resistance;
- Contrary to infrared sensors used in other missions, the microbolometer does not require cooling;
- This allows for a relatively low-cost mission with both sufficient sensitivity/spatial resolution as well as sufficient temporal resolution (large swath)

Result:

- High Revisit:
  - Multiple sensors packed in one satellite → large swath;
  - Low-cost microsatellite → makes constellation of satellites affordable.
- Short Data Latency:
  - Use of Canadian Ground Stations;
  - Maximum 30 min. latency.
- Routinely Scanning of the whole of Canada:
  - Low power needs allow for long-duration scanning.
### Capabilities of a SINGLE operational CWFMS Satellite

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<td>NETD &lt; 0.7 K @ 300 K</td>
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- High accuracy geo-referencing;
- Daily coverage of the whole of Canada;
- Low data latency (<30 minutes for priority data);
- Launch no earlier than 2022.
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- Daily coverage of the whole of Canada;
- Low data latency (<30 minutes for priority data);
- Launch no earlier than 2022.
Canadian Wildland Fire Monitoring System (CWFMS)

Number of Accesses with a 9-sat Operational CWFMS Constellation:

During the burning period of one day (09:00 – 21:00 local time)

During the PEAK burning period of one day (15:00 – 19:00 local time)
STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Tech Demo
Payload or Payload Component

Space Demo
Payload operated in space, User preparations (science & application development)

Space Worthiness

STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Operational
Full (commercial) space asset, Ground Segment & Operations, End-user products and downstream businesses

Proto-Operational
Single (gov) spacecraft, Simplified operations, Valued-added for Industry & Gov/Academic users

Service Try-out

CWFMS Implementation Steps

Technology & Application Readiness

Time
CWFMS Implementation Steps

STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

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Application Demonstration

STEP 4
Operational Use in Space

Scheduled for 2018 & 2019 with CFS & NRC

Tech Demo
Payload or Payload Component
Technical Feasibility

Space Demo
Payload operated in space, User preparations (science & application development)

Space Worthiness

STEP 2

STEP 3

STEP 4

Operational
Full (commercial) space asset, Ground Segment & Operations, End-user products and downstream businesses
Reliable Service

Proto-Operational
Single (gov) spacecraft, Simplified operations, Valued-added for Industry & Gov/Academic users
Service Try-out

Time
Airborne Campaign 2018-2019

- Collaboration between CSA, INO, NRCan-CFS, NRC, Ontario gov;
- Focus on coincident IR sampling with tower and aircraft mounted cameras;
- Burns in a variety of configurations at the Rose Experimental Burn Station near Sault Ste. Marie, Ontario, to verify performance.
STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Scheduled for 2018 & 2019 with CFS & NRC

ESAs/Belgian Collaboration Opportunity

Space Demo
Payload operated in space, User preparations (science & application development)

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Payload or Payload Component
Technical Feasibility

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Reliable Service

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Service Try-out

Time
ESA/Belgian Collaboration Opportunity

- Purpose: enhance operational ESA Proba-V (Vegetation) mission with a thermal dataset;
- 12Cubesat hosting Canadian instrument to fly in formation with existing Proba-V satellite;
- Launch of 12Cubesat intended for end of 2019;

Single MWIR/LWIR Instrument Concept Design
3-day revisit
STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Scheduled for 2018 & 2019 with CFS & NRC

Tech Demo
Payload or Payload Component
Technical Feasibility

Space Demo
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Reliable Service

Proto-Operational
Single (gov) spacecraft, Simplified operations, Valued-added for Industry & Gov/Academic users

Service Try-out

Implementation Steps

Technology & Application Readiness
STEP 1
Airborne Campaign

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Scheduled for 2018 & 2019 with CFS & NRC

Daily coverage with Canadian microsatellite

Tech Demo
Payload or Payload Component

Technical Feasibility

Space Demo
Payload operated in space,
User preparations (science & application development)

Space Worthiness

Time

Operational
Full (commercial) space asset, Ground Segment & Operations, End-user products and downstream businesses

Reliable Service

Protoperational
Single (gov) spacecraft, Simplified operations, valued-added for Industry & Academic users

Product Try-out

STEP 1

ESA/Belgian Collaboration Opportunity

STEP 2

STEP 3

STEP 4

Technology & Application Readiness

STEP 1

STEP 2

STEP 3

STEP 4
STEP 1
Airborne Campaign

STEP 2
Demonstration in Space
Payload operated in space, User preparations (science & application development)

STEP 3
Application Demonstration
Space Demo
Payload or Payload Component
Technical Feasibility

STEP 4
Operational Use in Space

- Operational
  - Full (commercial) space asset, Ground Segment & Operations, End-user products and downstream businesses
  - Reliable Service

Preparing for 2018 & 2019 with CFS & NRC

Daily coverage with Canadian microsatellite

9 sat constellation can provide scan of whole of Canada every 2-3 hours (commercial service?)

Operational

Scheduled for 2018 & 2019 with CFS & NRC

ESA/Belgian Collaboration Opportunity

STEP 2
Demonstration in Space

STEP 3
Application Demonstration

STEP 4
Operational Use in Space

Simplified operations, Valued-added for Industry & Academic users

Proto-Operational

Reliable Service
STEP 4: Operational Constellation

- Interest coming up from commercial entities to build a thermal constellation or include thermal observations in constellations;
- Specific technology needed for this application has not been demonstrated in space by any nation;
- CWFMS demonstration will put Canada on the map to supply the infrared detector technology for such initiatives.
Earth Observation Summit 2017
Montreal, June 20 – 22

- 3-day Workshop dedicated to Wildfire Remote Sensing (RS)
- 50+ participants from 6 countries;
- 29 presentations, 2 panel discussions:
  - Bridging Research & Reality
  - Air, Ground and Space helping each other out
- 30 needs/challenges/lessons identified;
- Recommendation relevant to CWFMS:
  - Put equal emphasis on improvements on data availability (needs from the operational community: how fast can you get it, frequency, reliability and continuity) as on data quality (usual focus of the research community, e.g. accuracy of the measurement);
Conclusion

- There is a need in Canada for frequent fire monitoring data;
- A low-cost satellite system solution exists, based on microbolometer technology:
  - ‘Good-enough’ sensitivity approach;
  - Combining relatively high spatial/temporal resolution.
- CSA-CFS-NRC are preparing an airborne campaign for summer 2018;
- Discussions are on-going with Belgium/ESA for a technology demonstration opportunity.
Questions?
Contact Information

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Canadian Space Agency (CSA)
Tel : (450) 926-7754 / helena.vanmierlo@canada.ca
Back-up Slides
## CSA Investment History

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<th>Description</th>
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<td>1995</td>
<td>Start of Canada investing in the development of microbolometer technology for thermal imaging</td>
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<tr>
<td>2007</td>
<td>Start of CSA investing in the development of microbolometer technology for the <em>fire application</em>.</td>
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| 2011 | Technology demonstration of early design in space
  - Was designed for Long-Wave InfraRed (LWIR) so exhibited less adequate performance at Mid-Wave InfraRed (MWIR);
  - Without in-flight calibration capability |
| 2016 | Completion of feasibility study (CWFMS\(^2\)) of a Canadian microsatellite with the latest microbolometer technology
  - Optimum designs for Long-Wave and Mid-Wave InfraRed (LWIR/MWIR) measurements |

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1. The New InfraRed Sensor Technology (NIRST) was demonstrated with partial results on the NASA Aquarius mission on-board the Argentine SAC-D spacecraft from 2011-2015.

2. CWFMS – Canadian Wildland Fire Monitoring System
Current State of the Art

- Payload with 3 MWIR + 3 LWIR cameras will provide daily global map;
- Each camera’s detector is a linear array of 1017x3 pixels;

### Payload Accommodation Needs

<table>
<thead>
<tr>
<th></th>
<th>Mass (kg)</th>
<th>Volume (mm³)</th>
<th>Orbit Average Power (W)</th>
<th>Peak Power (W)</th>
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<tr>
<td></td>
<td>41</td>
<td>200 x 536 x 534</td>
<td>16</td>
<td>75</td>
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### Spectral band (μm) and Purpose

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CWFMS Resolution (Simulated Data)

CWFMS (450 m)

MODIS (1000 m)