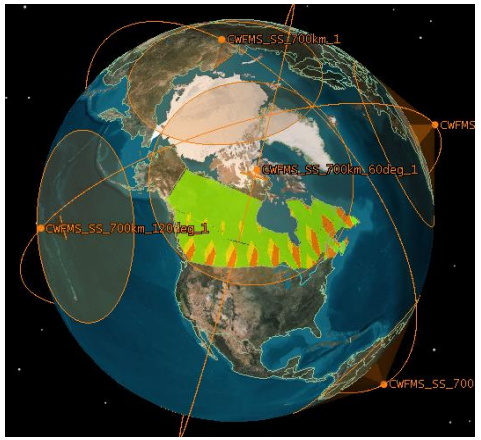
The Canadian Wildland Fire Monitoring Sensor (CWFMS) Mission Proposal

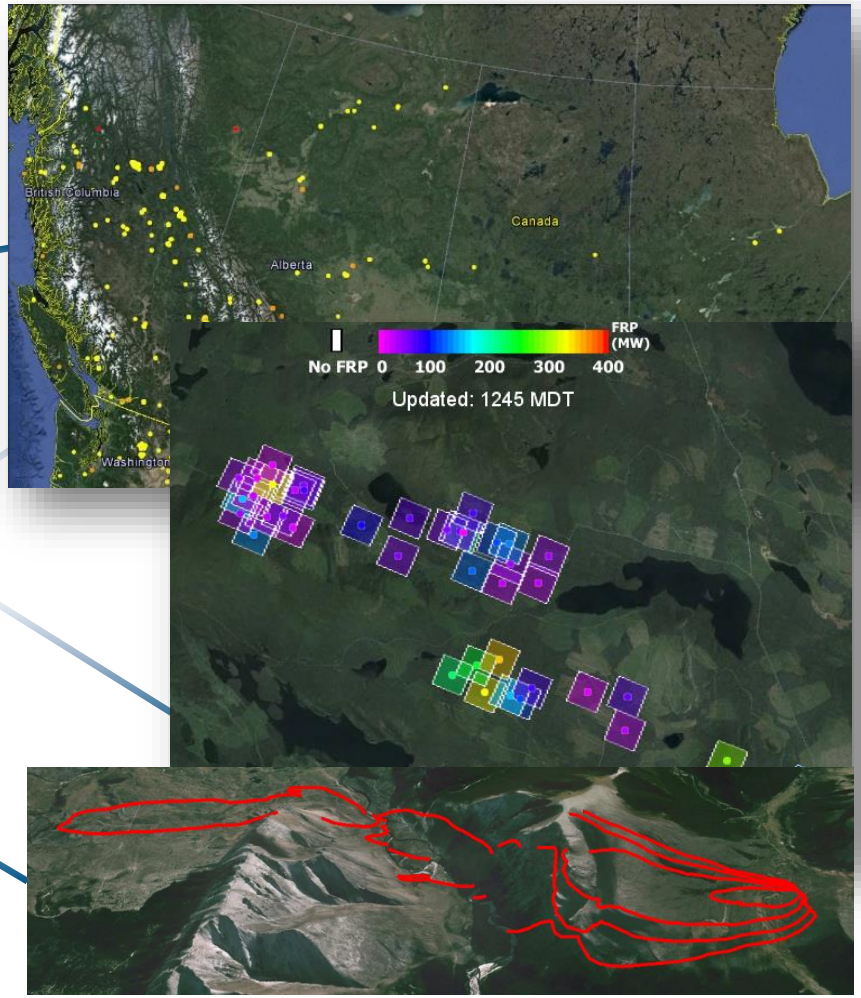


Helena van Mierlo
Canadian Space Agency

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

Spectral Band	(µm)	Purpose
Visible – Near Infrared (VNIR)	0.5-0.6 0.6-0.7 0.8-0.9	• Cloud mapping • Burned area mapping
Short-Wave Infrared (SWIR)	1.6-1.7	• To improve burned area mapping
Mid-Wave Infrared (MWIR)	**3.5-4.2**	• **High Temperature Event (HTE) detection** • **Fire Radiative Power (FRP) measurement**
Long-Wave Infrared (LWIR)	10.4-12.3	• Surface temperature characterization • False detection (sun-glint) identification • Cloud rejection • Bi-spectral methods for sub-pixel fire characterization

To obtain ENERGY

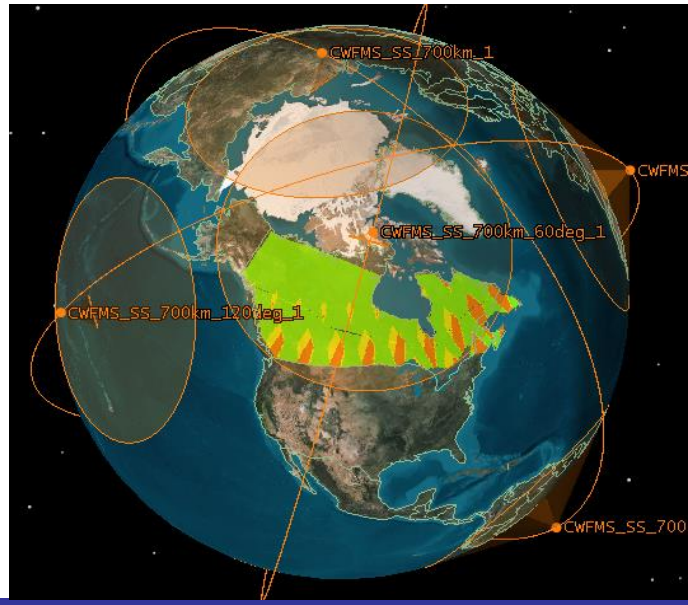
Measurements Needed by the Users

- 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

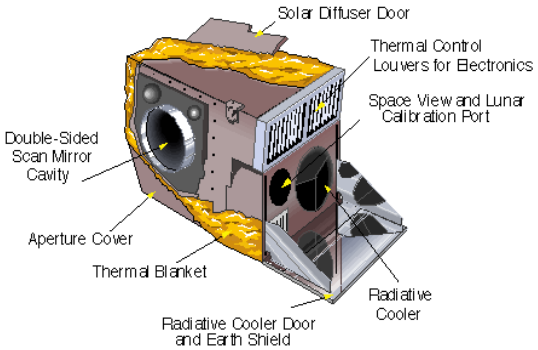
With a constellation of satellites

Affordable with low-cost satellites



Space Missions
With Fire Monitoring Capability

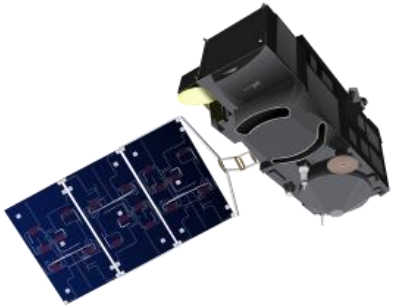
MODIS



VIIRS

AVHRR

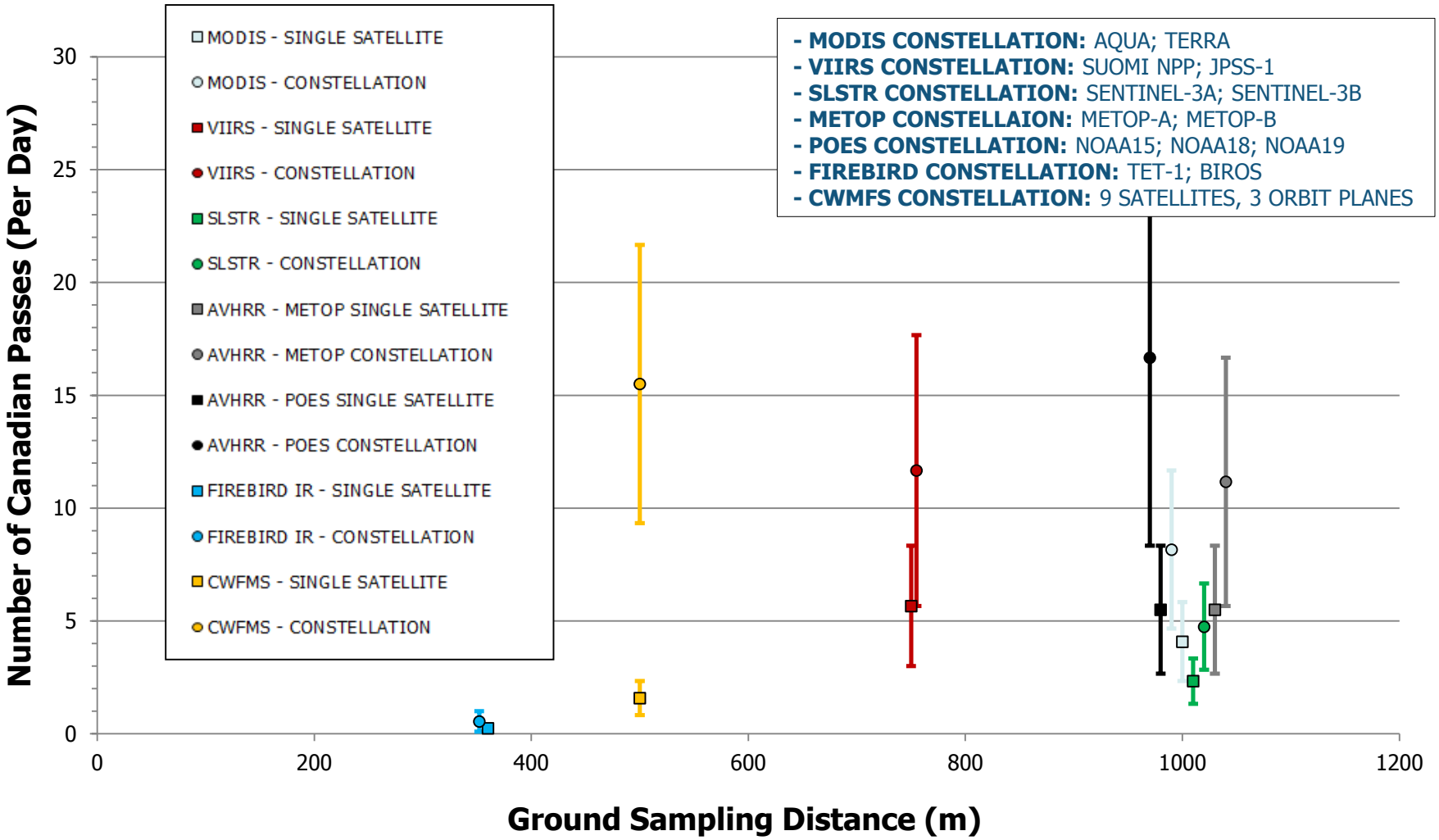
SLSTR



FIREBIRD

GOES

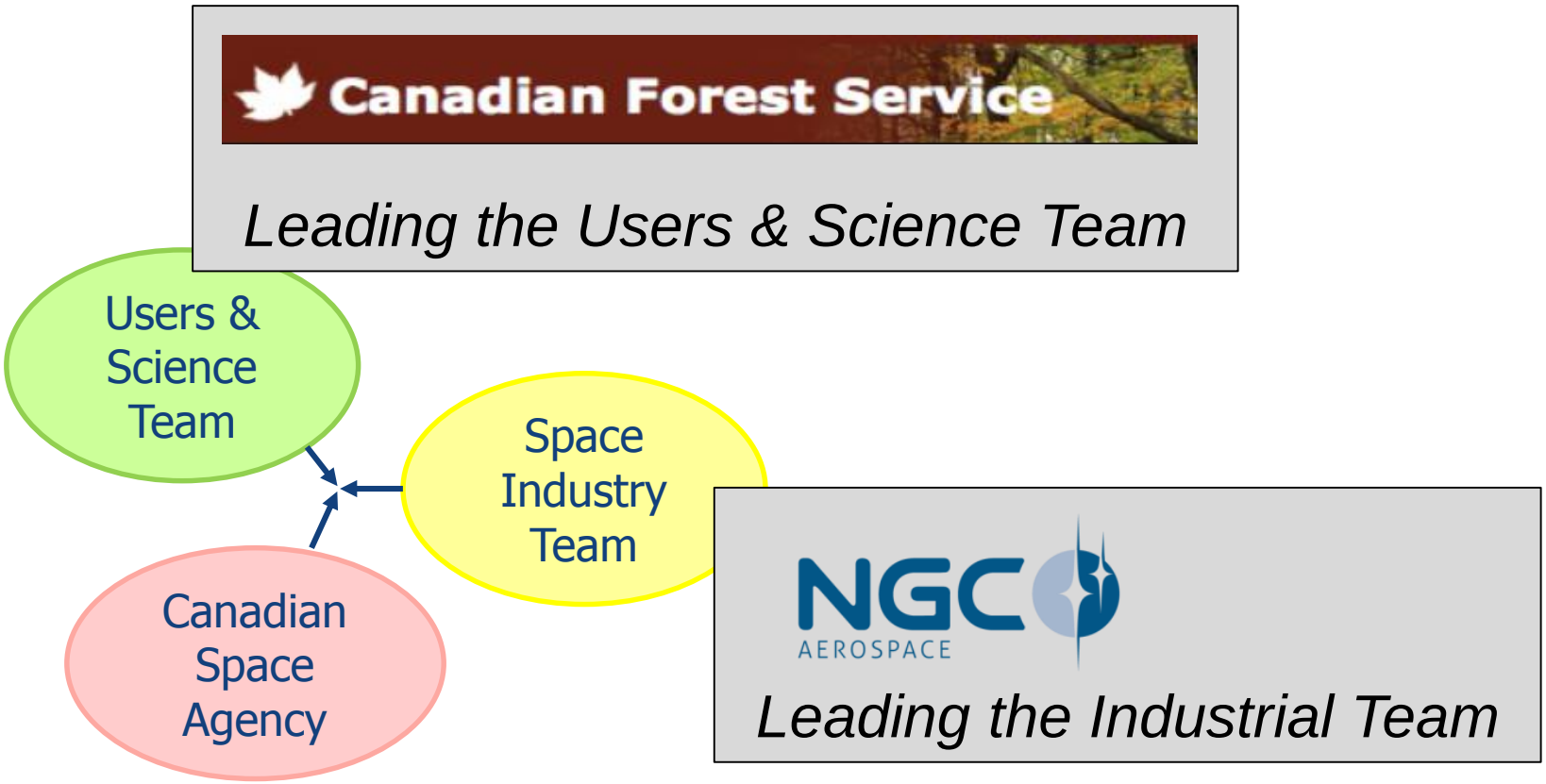
CWFMS Comparison with Other Satellites
Revisit against Ground Sampling Distance (GSD)



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.

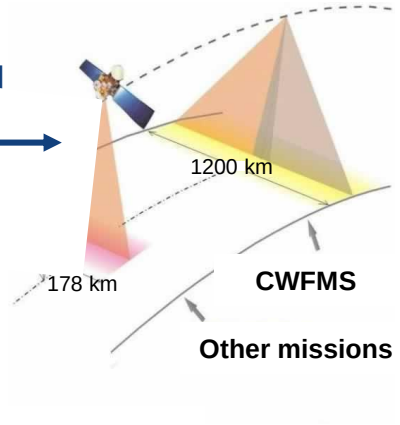
CWFMS Mission Feasibility Study
(completed in 2016)



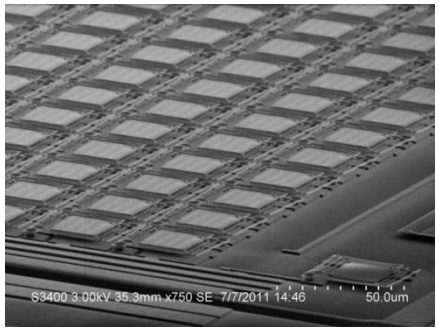
A Canadian Solution:
Uncooled Infrared Detector Technology

- 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)

LOW COST – LOW POWER
LOW VOLUME – LOW MASS



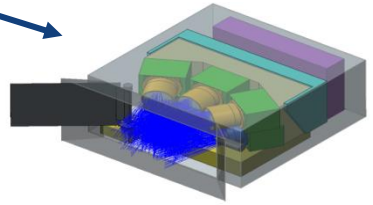
Canadian **UNCOOLED** infrared detector technology



INO

Result:

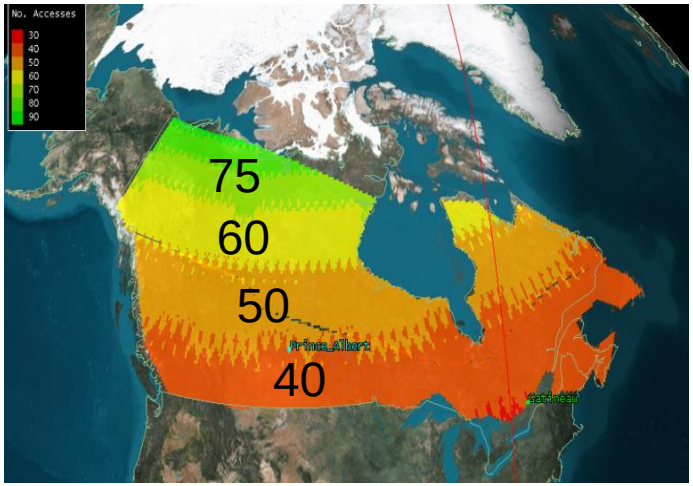
- **High Revisit:**
  - Multiple sensors packed in one satellite → large swath;
  - Low-cost microsatellite → makes constellation of satellites affordable.
- **Short Data Latency:**
  - Use of Canadian Ground Stations;
  - Maximum 30 min. latency.
- **Routinely Scanning of the whole of Canada:**
  -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



Capabilities of a SINGLE operational CWFMS Satellite

Spectral Band (µm)		Purpose	GSD (m)	Sensitivity	Dynamic Range
VNIR	0.5-0.6 0.6-0.7 0.8-0.9	For loud mapping and burned area mapping	250	SNR > 200	< 500 $W \cdot m^{-2} \cdot \mu m^{-1} \cdot sr^{-1}$
SWIR (optional)	1.6-1.7	To improve burned area mapping	250	SNR > 100	
MWIR	3.5-4.2	For High Temperature Event Detection and FRP measurement	500	NETD < 0.3 K @ 400 K	300 – 610 K
LWIR	10.4-11.3	Surface temperature characterization, false detection (sun-glint) identification, loud rejection and bi-spectral methods for sub-pixel fire characterization		NETD < 0.7 K @ 300 K	300 – 440 K
	11.4-12.3				

Number of passes during one month by one operational CWFMS Satellite:



- 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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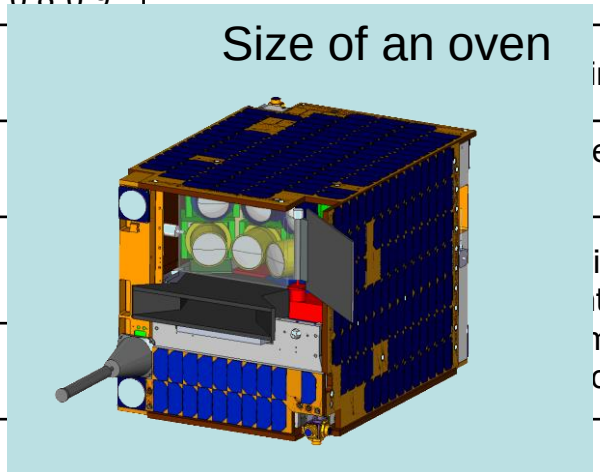

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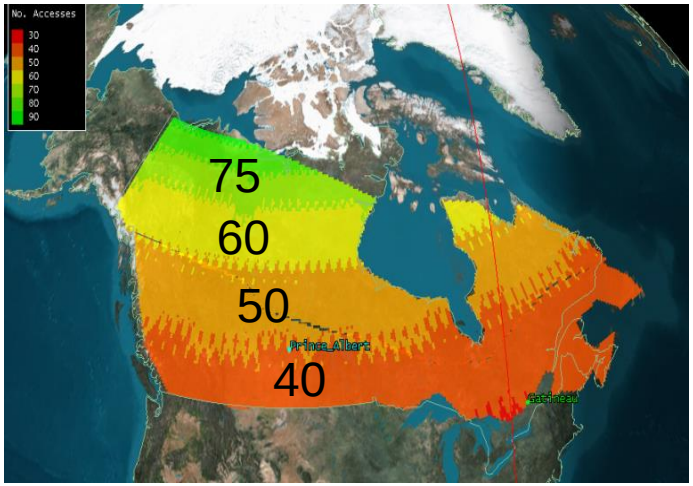
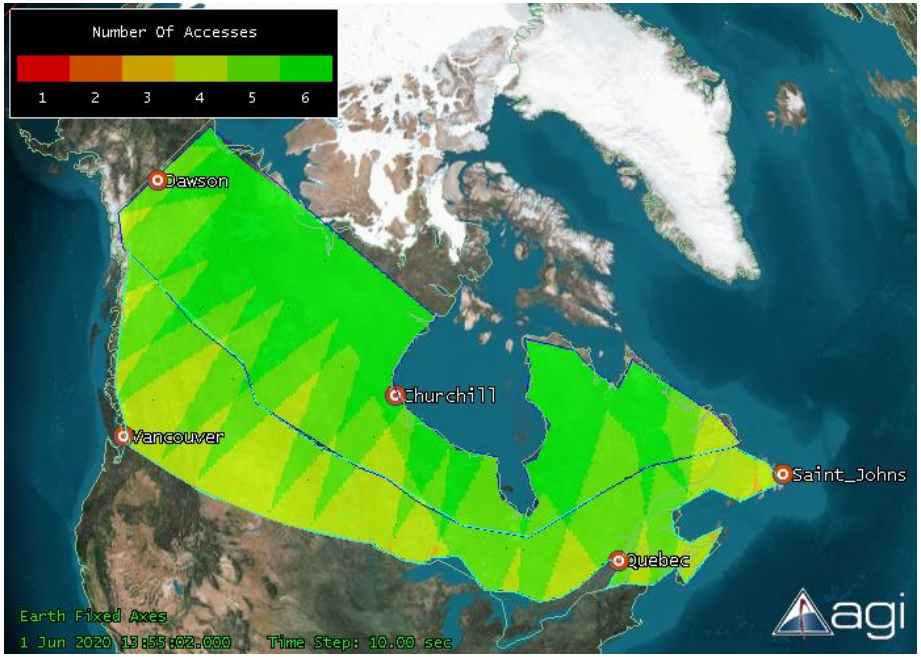


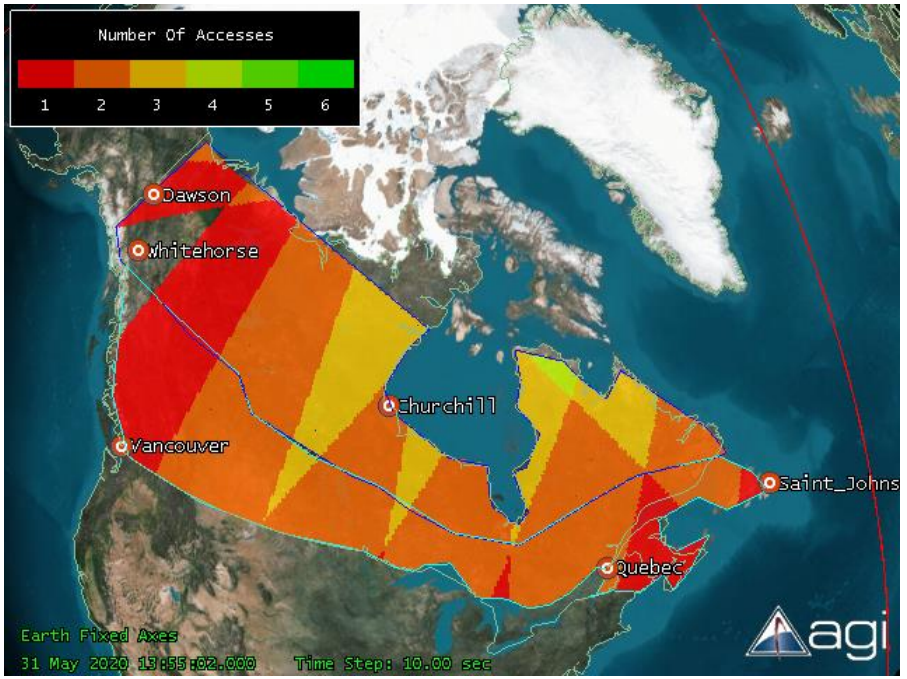
Canadian Wildland Fire Monitoring System (CWFMS)

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)



CWFMS Implementation Steps

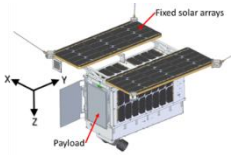
Technology & Application Readiness

Time

STEP 1
Airborne Campaign

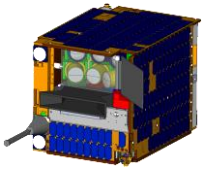
Tech Demo
Payload or Payload Component
Technical Feasibility

STEP 2
Demonstration in Space



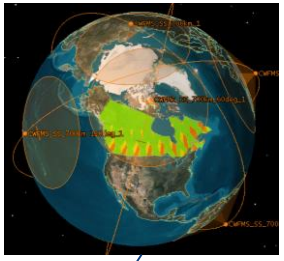
Space Demo
Payload operated in space, User preparations (science & application development)
Space Worthiness

STEP 3
Application Demonstration



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

STEP 4
Operational Use in Space



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

CWFMS Implementation Steps

Scheduled for 2018 & 2019 with CFS & NRC

Technology & Application Rea

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Payload or Payload Component
Technical Feasibility

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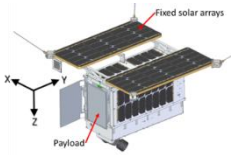

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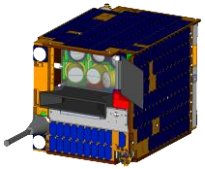

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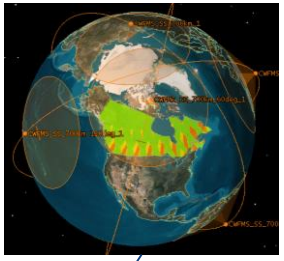

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Airborne Campaign 2018-2019

- Collaboration between CSA, INO, NRCan-CFS, NRC, Ontario gov;
- Focus on coincident IR sampling with tower and aircraft mounted cameras;

NRC Twin Otter

- Burns in a variety of configurations at the Rose Experimental Burn Station near Sault Ste. Marie, Ontario, to verify performance.

Implem eps

Scheduled for 2018 & 2019 with CFS & NRC

ESA/Belgian Collaboration Opportunity

Technology & Application Rea

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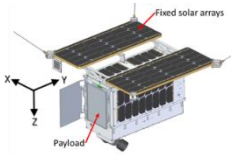

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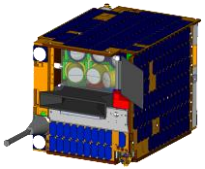

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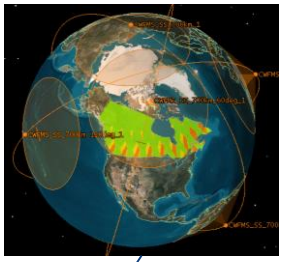

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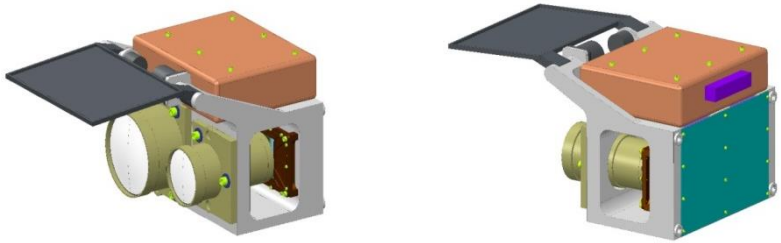
Time

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

Implem eps

Scheduled for 2018 & 2019 with CFS & NRC

ESA/Belgian Collaboration Opportunity

Technology & Application Rea

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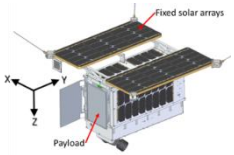

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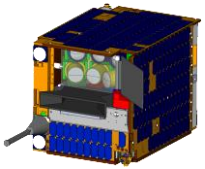

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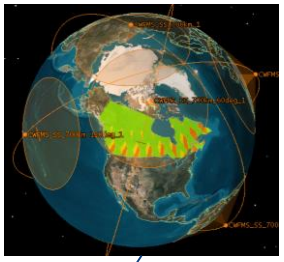

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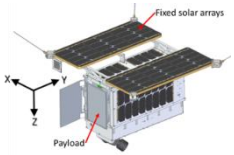

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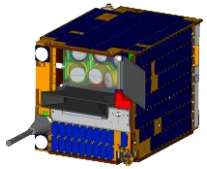

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Daily coverage with Canadian microsatellite

STEP 4
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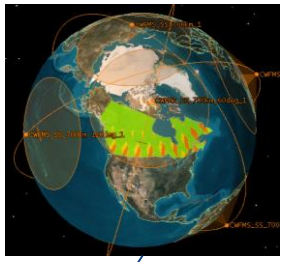

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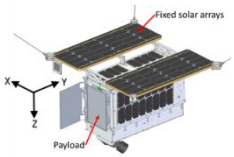

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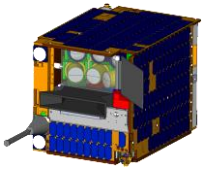

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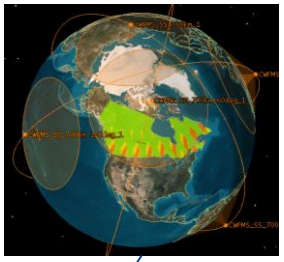

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9 sat constellation can provide scan of whole of Canada every 2-3 hours (commercial service?)

Time

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 <u>Wildfire Remote Sensing (RS)</u>**
- 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 <u>data availability</u> (needs from the operational community: how fast can you get it, frequency, reliability and continuity) as on <u>data quality</u> (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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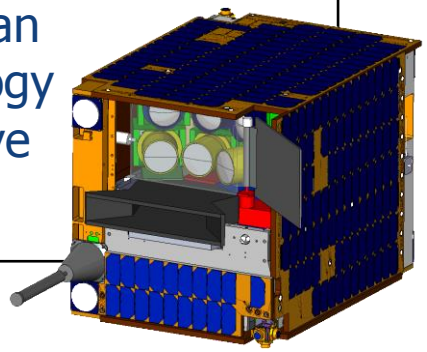
Canadian Space Agency (CSA)
Tel : (450) 926-7754 / helena.vanmierlo@canada.ca

Back-up Slides

CSA Investment History

1995	Start of Canada investing in the development of microbolometer technology for thermal imaging
2007	Start of CSA investing in the development of microbolometer technology for the fire application.
2011	Technology demonstration of early design in space[1] • 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

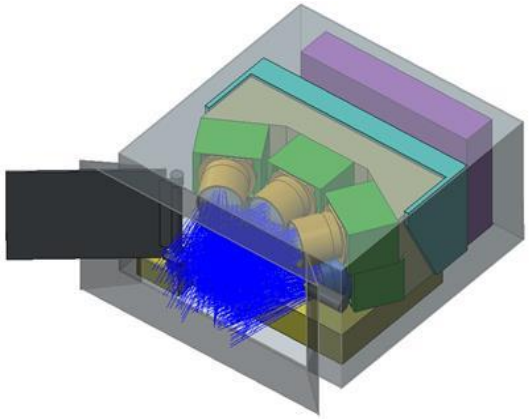


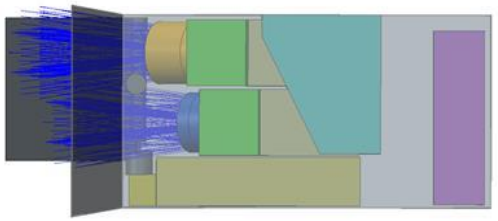
1. The New InfraRed Sensor Technology (NIRST) was demonstrated with partial results on the NASA Aquarius mission on-board the Argentine SAC-D spacecraft from 2011-2015.

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	
Mass (kg)	41
Volume (mm^3)	200 x 536 x 534
Orbit Average Power (W)	16
Peak Power (W)	75

Spectral band (µm)		Purpose	GSD (m)	Sensitivity	Dynamic Range
MWIR	3.5-4.2	For High Temperature Event (HTE) Detection and Fire Radiative Power (FRP) measurement	400	NETD < 0.3 K @ 400 K	300 - 610 K
LWIR	10.4-12.3	Surface temperature characterization, false detection (sun-glint) identification, cloud rejection and bi-spectral methods for sub-pixel fire characterization.		NETD < 0.7 K @ 300 K	300 - 440 K

CWFMS Resolution (Simulated Data)