CRAFT PROSPECT

a space engineering practice

EDHPC 2023
European Data Handling &
Data Processing Conference for Space
2 - 6 October 2023 | Juan-Les-Pins | France

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A Modular, Reconfigurable and Portable Framework for On-Board Data Processing: Architecture and Applications

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European Data Handling & Data Processing Conference 2023, Juan-Les-Pins

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- Architecture
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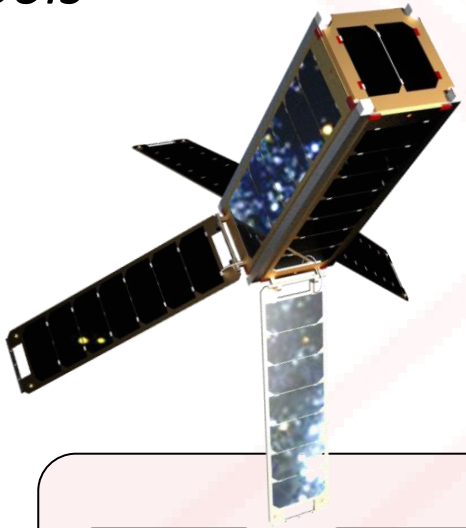
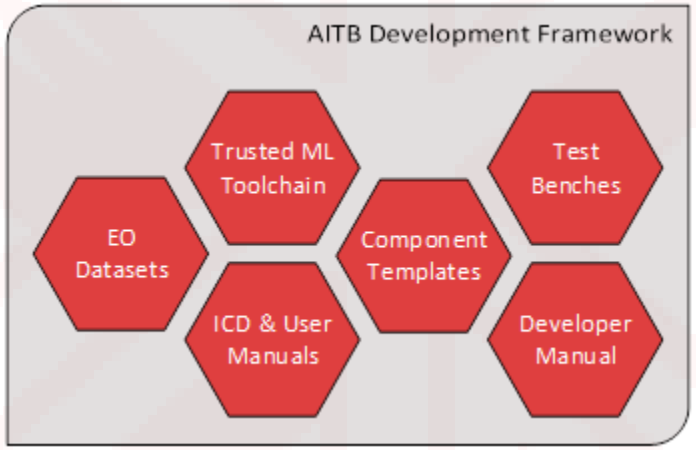
- Roadmap and Future

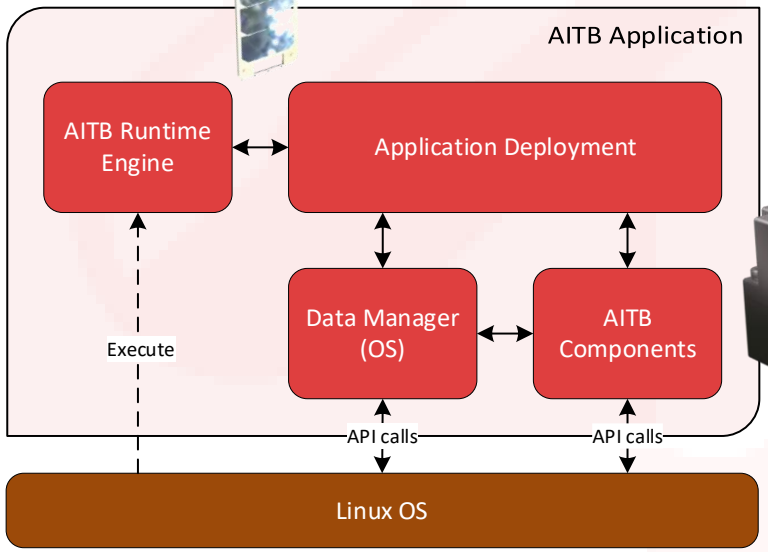
Astral Intelligence Toolbox

Application Development Framework & Tools

- Modular components for space mission autonomy and on-board data processing
- Rapid deployment toolchain
- Benefits:
  - Readily configurable for different applications
  - Platform-agnostic
  - Assured component to system level
  - Tailored to meet mission safety and performance requirements







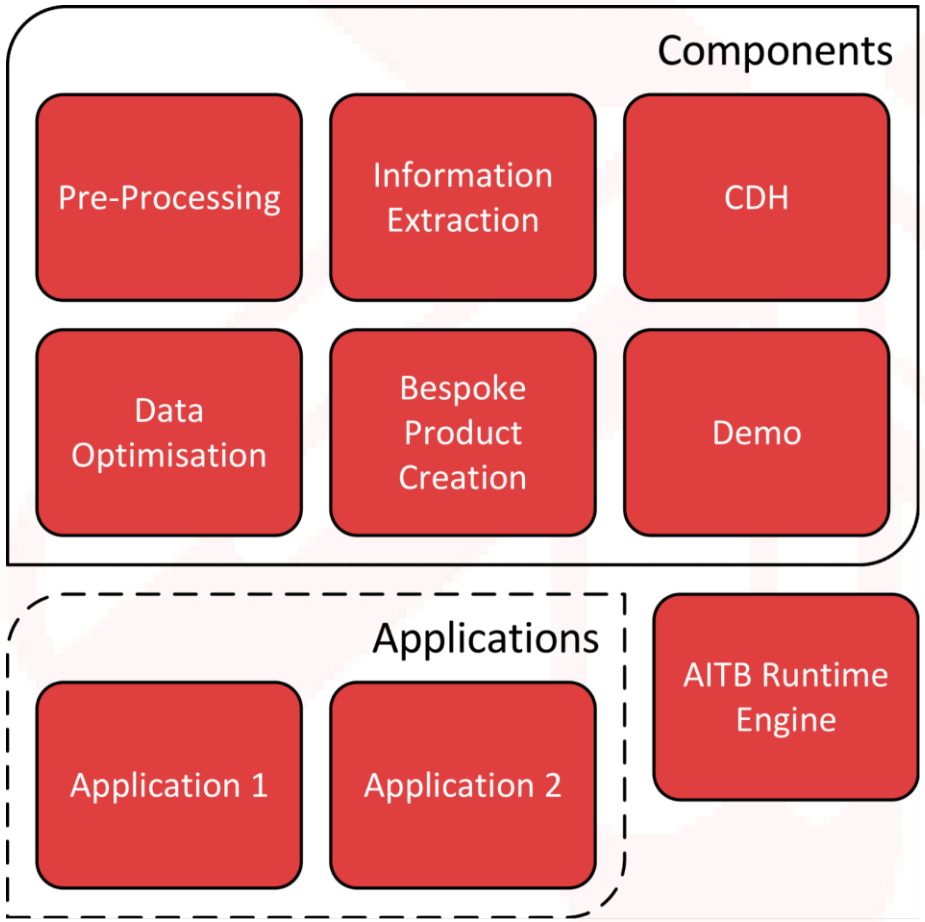
Framework Requirements

Driving requirements of the AITB for payload data processing:

- Employ a component-based approach to aid re-use, unit testing, continuous development and portability
- Allow simple, run-time configuration of key component parameters
- Allow targeting of new instruments and target platforms with minimal impact on existing component source code.
- Facilitate the generation of customer-focussed mission metrics – cost, quality, timeliness, readability and trustworthiness.
- Enable a balance between feasible, in-orbit solutions and high performance.

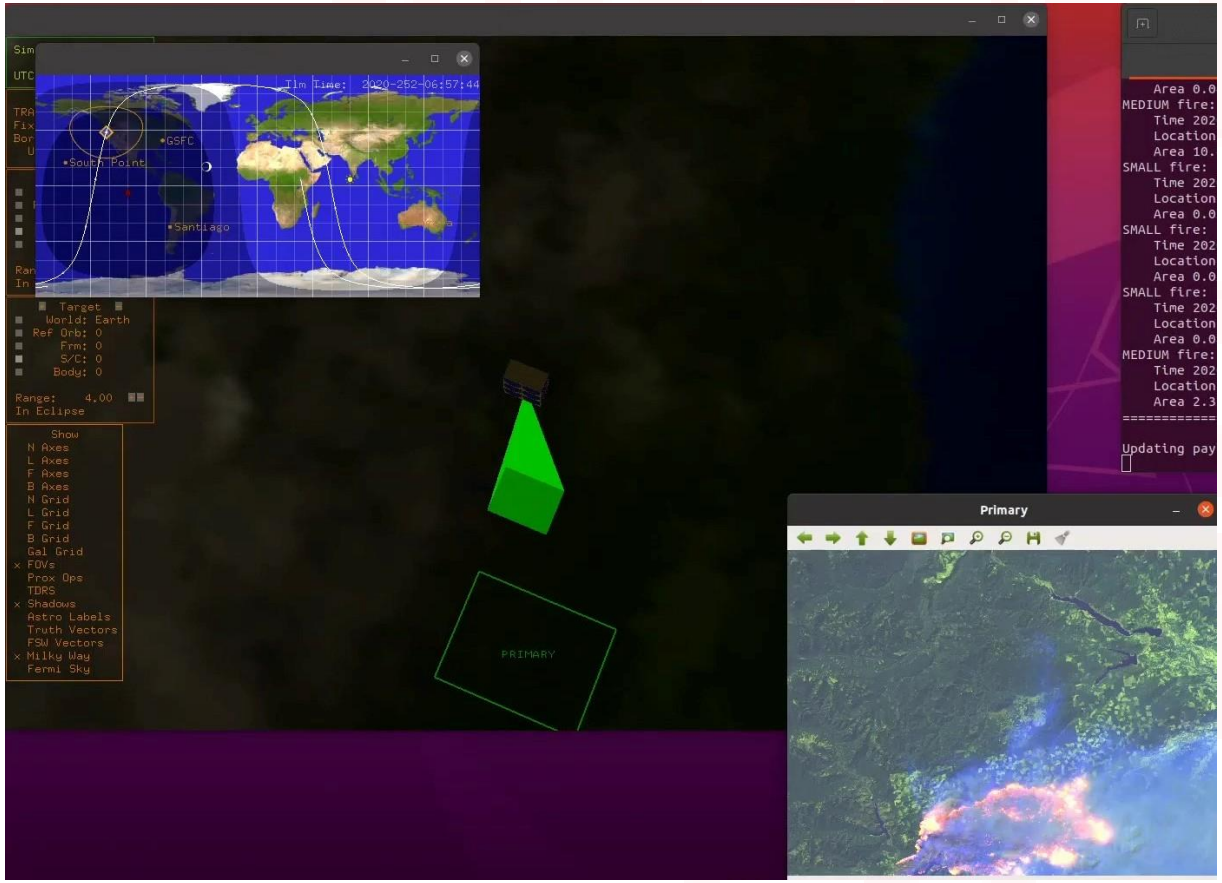
Architecture

- AITB components are grouped into task categories, e.g data handling, information extraction (using ML), raw data pre-processing, etc.
- Components can be combined as Applications to perform end-to-end processing activities
- The runtime engine handles processing iterations component addressing



Testing

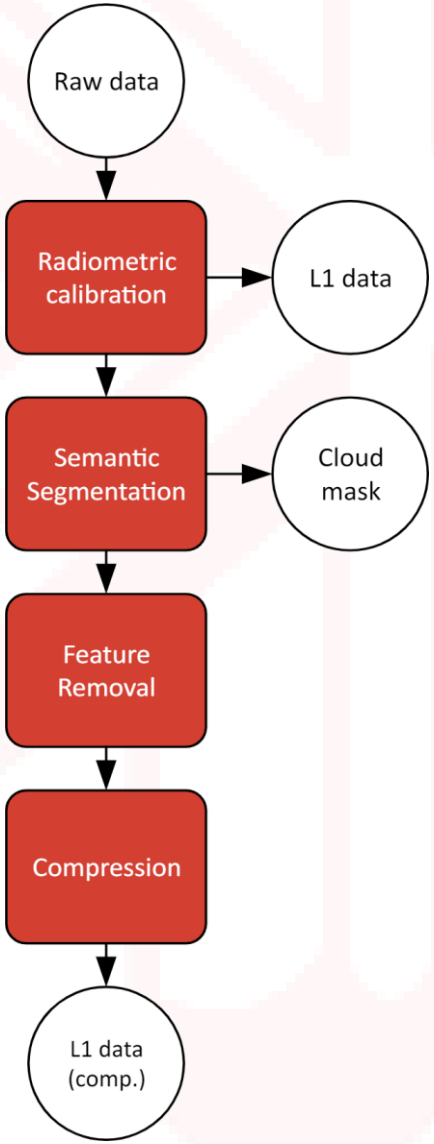
- Built-in unit tests for each component
- Application-tailored evaluation components to generate performance metrics at runtime
  - Latencies
  - ML model accuracy
  - Deployable within flight configurations
- Simulation test harness for mission-level functional and performance testing



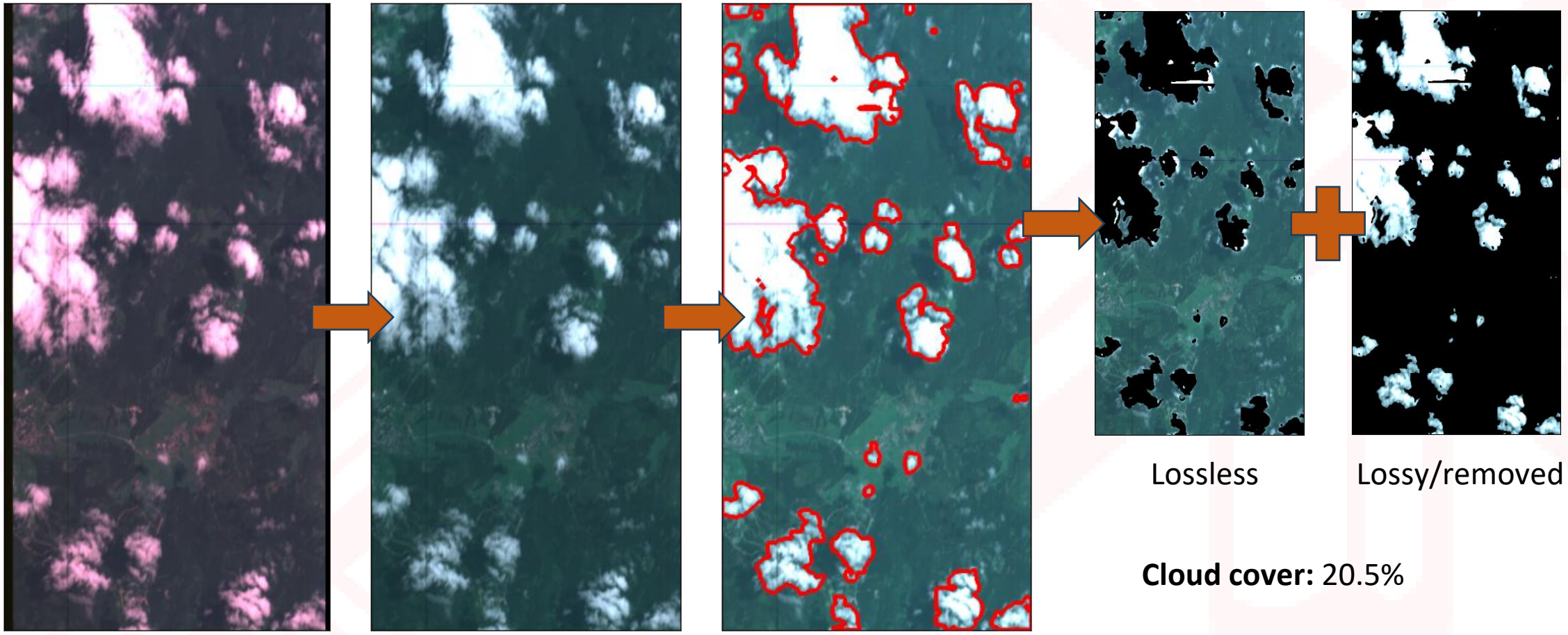
Case Study: Hyperspectral Data Reduction

Requirements

- Process raw data into a “science-ready” product (top-of-the-atmosphere reflectance)
- Reduce compressed file size relative to standard CCSDS 122 file
- Increase the number of useful data products per downlink



Case Study: Hyperspectral Data Reduction



Raw (decoded)

Calibrated

Cloud masks

Lossless

Lossy/removed

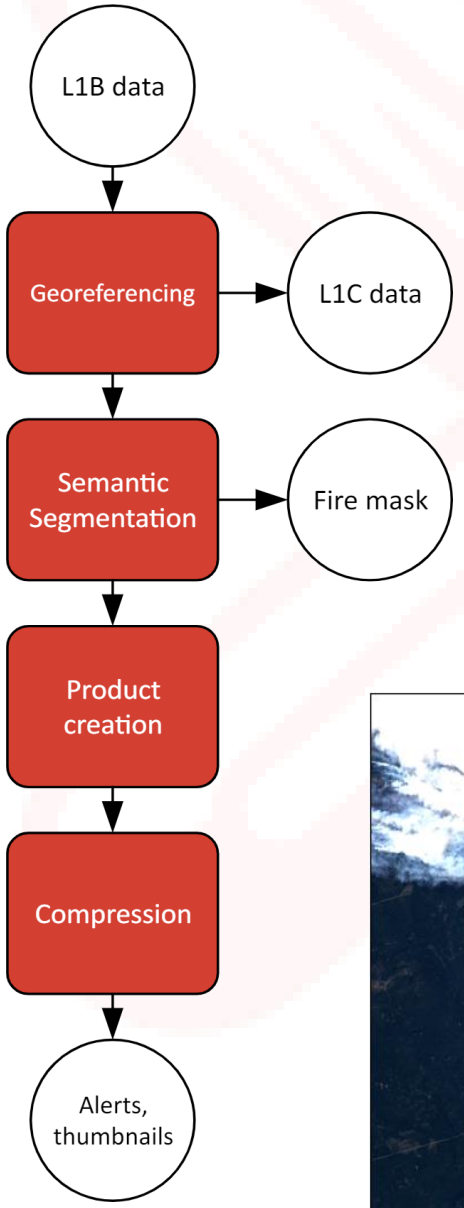
Cloud cover: 20.5%

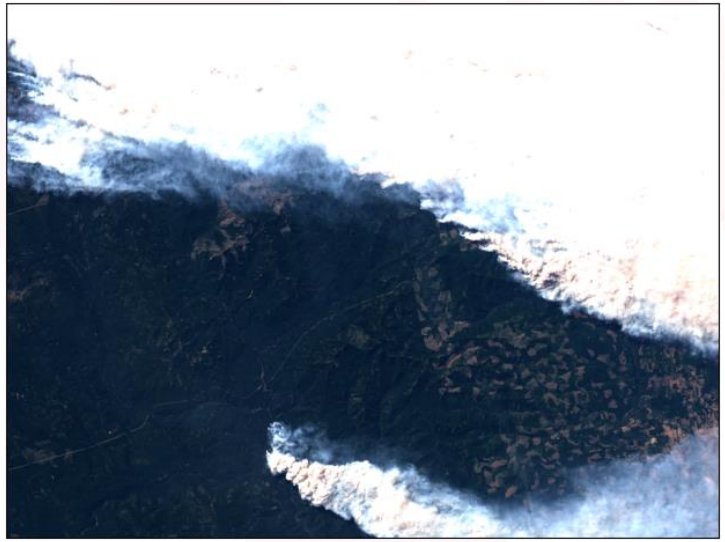
Compression gain vs standard CCSDS 122: 1.35

Case Study: Wildfire Alerting

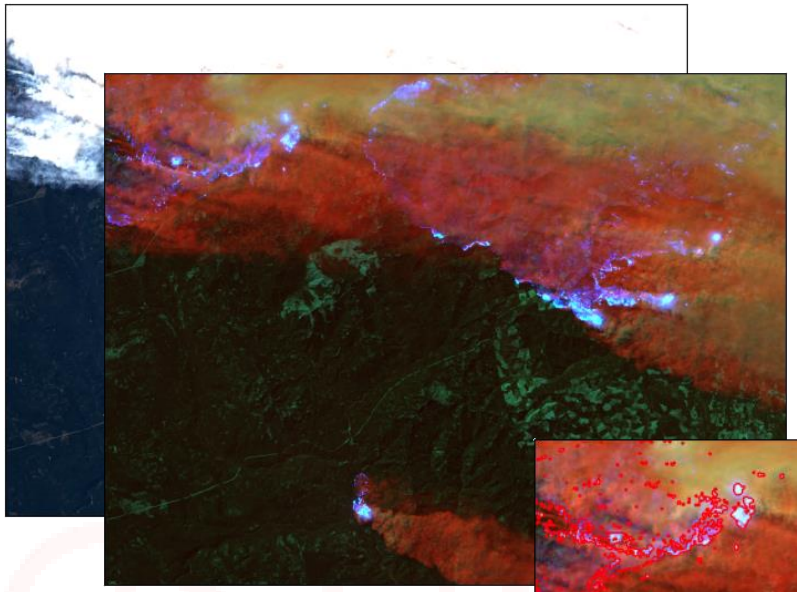
Requirements

- Process multispectral data into actionable information (a human-readable alert message)
- Deliver verification products to supplement alert, such as annotated, lightweight image files and product metadata
- Meet end user-defined targets for classification accuracy



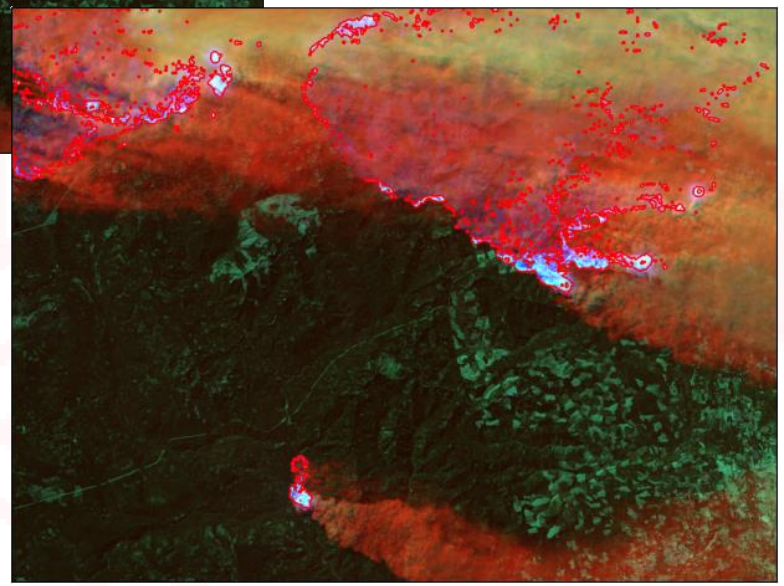


Case Study: Wildfire Alerting



Multispectral data

Type	Metric	Value
Accuracy	MeanIoU	93%
	True Positive (fires)	99.6%
	True Negative (clear)	97.2%
Latency	Input image to alert generation	4.84 s



Wildfire masks

```
FIRES DETECTED
MEDIUM fire:
    Time 20200908-065757.184
    Location (45.07128°N, 122.06470°W)
    Area 2.69 sq km
SMALL fire:
    Time 20200908-065757.184
    Location (44.90863°N, 122.30477°W)
    Area 0.70 sq km
LARGE fire:
    Time 20200908-065757.184
    Location (44.93701°N, 122.39759°W)
    Area 19.39 sq km
SMALL fire:
    Time 20200908-065757.184
    Location (44.89978°N, 122.29067°W)
    Area 0.03 sq km
```

Low latency products

Verification thumbnail

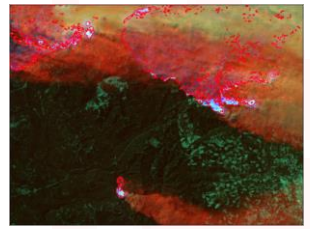
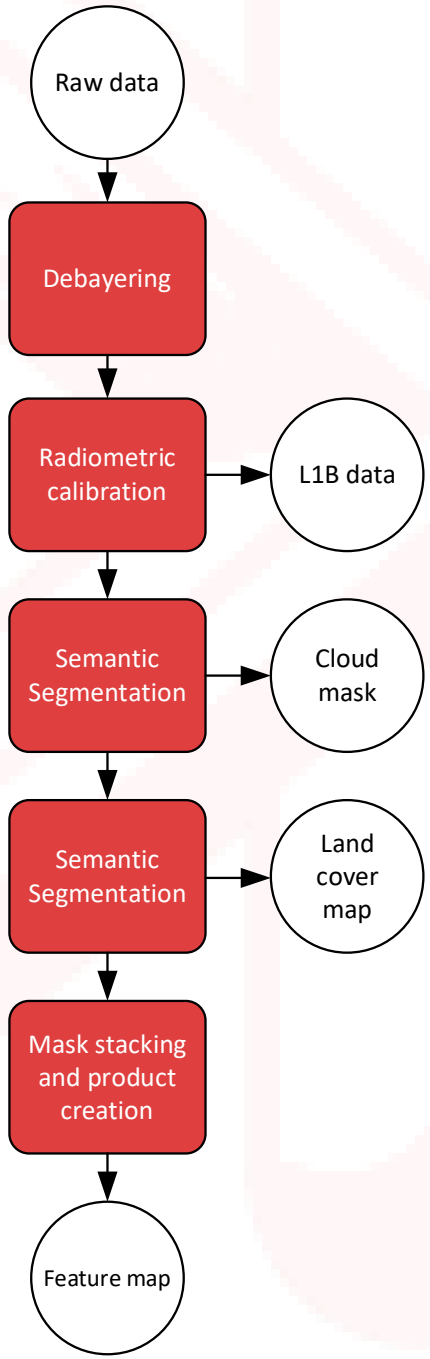


Image product metadata

Case Study: Land Cover Thematic Mapping

Requirements

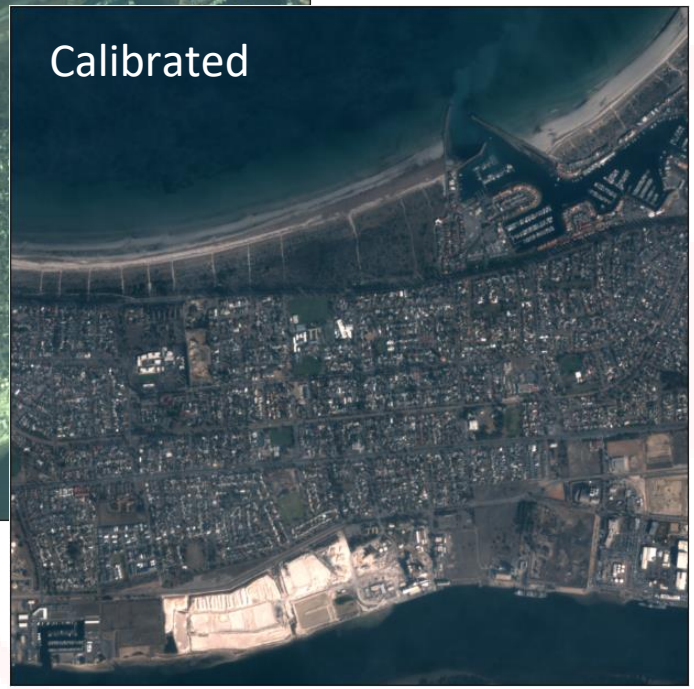
- Process raw data into a “science-ready” product (top-of-the-atmosphere reflectance)
- Reduce low-value (i.e. cloudy) data
- Generate human-readable land cover maps
- Increase the number of useful data products per downlink

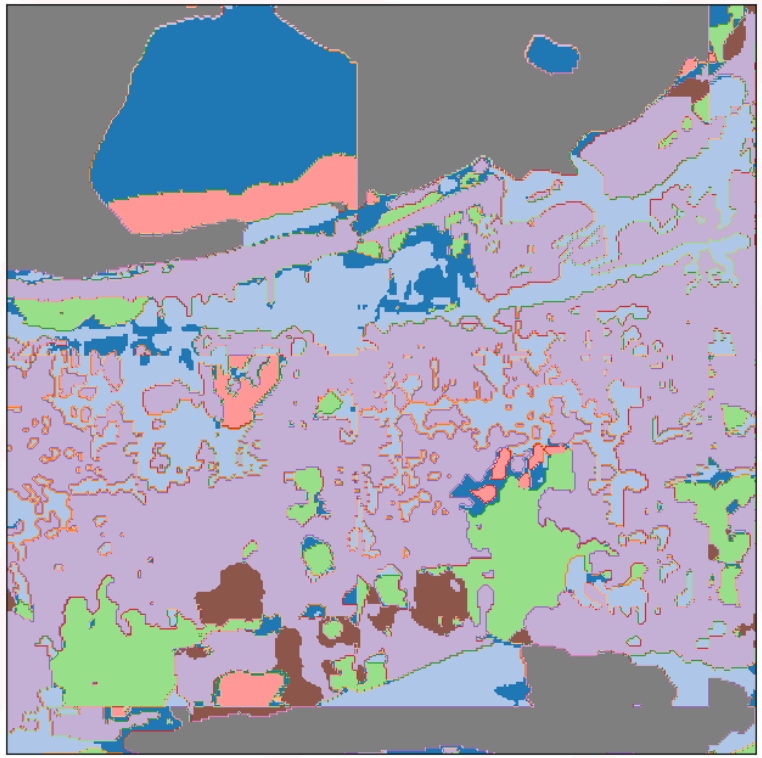


Case Study: Land Cover Thematic Mapping

Bayer pattern

Debayered





Roadmap and Future

- Flight heritage
  - Cloud masking component expected imminently
  - First generation Forwards Looking Imager in 2024
    - Including cloud classification and geolocation
  - Full AITB applications from 2024
- Future work
  - AITB to provide processing and decision-making backbone of second generation Forwards Looking Imager
  - Dedicated AITB data processing module under development
  - Development of mission-critical functionality
    - Real-time tasking, mission planning and closed-loop control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