ARDC Bushfire Data Challenge – Work Package 5: Approach Report

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Summary:

Through the Australian Research Data Commons (ARDC) Bushfire Data Challenge, the Emergency Management Spatial Information Network Australian (EMSINA) and Geoscience Australia (GA) aim to develop a National Bushfire History. The data will include a time-series of nationally aggregated burnt extent, and will be produced through collaboration with National, State and Territory agencies. Work Package Five (WP5) of the ARDC Bushfire History project will implement a suite of automated Earth observation based algorithms, currently in use by State and Territory agencies, to produce a range of national data products describing the timing, location and extent of bushfires across Australia. This work package will leverage and complement work underway by EMSINA as part of Work Package four (WP4) that is bringing together existing and carefully audited state datasets of bushfire extent compiled directly by State and Territory agencies via a range of operational approaches.

This work has been supported by the Australian research Data Commons (ARDC) and the Minderoo Foundation.

Work Package 5a: Burnt area mapping approach report

Final Draft

17 August 2022

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Table of Contents

1 Executive Summary

Through the Australian Research Data Commons (ARDC) Bushfire Data Challenge, the Emergency Management Spatial Information Network Australian (EMSINA) and Geoscience Australia (GA) aim to develop a National Bushfire History. The data will include a time-series of nationally aggregated burnt extent, and will be produced through collaboration with National, State and Territory agencies. Work Package Five (WP5) of the ARDC Bushfire History project will implement a suite of automated Earth observation based algorithms, currently in use by State and Territory agencies, to produce a range of national data products describing the timing, location and extent of bushfires across Australia. This work package will leverage and complement work underway by EMSINA as part of Work Package four (WP4) that is bringing together existing and carefully audited state datasets of bushfire extent compiled directly by State and Territory agencies via a range of operational approaches.

Different applications of burnt area information have varying requirements which often depend on the jurisdiction. This project does not intend to replace systems and data developed and operated by different State and Territory agencies. Rather the objective is to provide a nationally and temporarily consistent view on fire activity that can complement these existing systems and data.

The objectives of the initial burnt area mapping system will be to implement four state-based burnt area mapping algorithms within the Digital Earth Australia platform. Specifically, these algorithms are:

1. BurnCube (Geoscience Australia, Renzullo et al. 2019)
2. dNBR (Geoscience Australia)
3. Qld RapidFire (Queensland Government)
4. Vic/NSW RandomForest (Victorian and New South Wales Governments)

Each of these algorithms will be run at National scale, resulting in four maps of potential burnt area, that can complement state based burnt area mapping. Over time this system could incorporate new approaches developed within the research community or within State and Territory bushfire management agencies.

Algorithms will be provided with a confidence estimate, which may include validation based on algorithm performance, extent of training data and independent validation, including that available through other work packages. The system will not provide a best estimate of burnt area, or best available mapping. Rather, the data will be considered as a complementary information source for jurisdictions to incorporate into their own assessments of the best estimate of burnt area.

2 Introduction

Mapping of bushfire burnt areas is currently performed by all State and Territory Governments in order to provide an authoritative account of areas impacted. Methods used to map burnt areas vary between and within agencies, and can include ground observations, manual interpretation of high resolution aerial and satellite imagery, and automated processing of satellite imagery. The form of a burnt area map for a single event may go through multiple iterations, as new data is incorporated into the analysis, and will generally be recorded as a vector polygon, or multiple polygons describing the final burnt area boundary. Once approved by the relevant agency, this will be incorporated into a jurisdictional Fire History data layer that can be used for analysis of impacts, drivers and residual bushfire risk.

The 2020 Royal Commission into National Natural Disaster Arrangements recognised the high level of professionalism and sophistication of information systems used by State and Territory agencies for bushfire management. They also identified a number of benefits of developing and sharing nationally consistent data related to bushfire risk and impacts. Key recommendations by the Royal Commissions relevant to burnt area mapping include:

- Recommendation 4.1 National disaster risk information: Australian, state and territory governments should prioritise the implementation of harmonised data governance and national data standards.
- Recommendation 4.7 Collection and sharing of impact data: Australian, state and territory governments should continue to develop a greater capacity to collect and share standardised and comprehensive natural disaster impact data.

Key benefits of a national system for delivery of bushfire burnt areas include providing all relevant agencies with a broad set of data (field observations, aerial and satellite imagery) and algorithms (particularly automated image processing) in order to more accurately estimate impacts, train bushfire behaviour models and understand future bushfire risk. In this way a national burnt area mapping system may not necessarily be the authoritative dataset at the state level, but may supplement decision making with information that would otherwise not be available within a given jurisdiction.

Figure 1 shows the ultimate vision for the National Bushfire History information systems, where authoritative state-based data is brought together with remote sensing data products to help build a consistent and timely picture of bushfire impacts

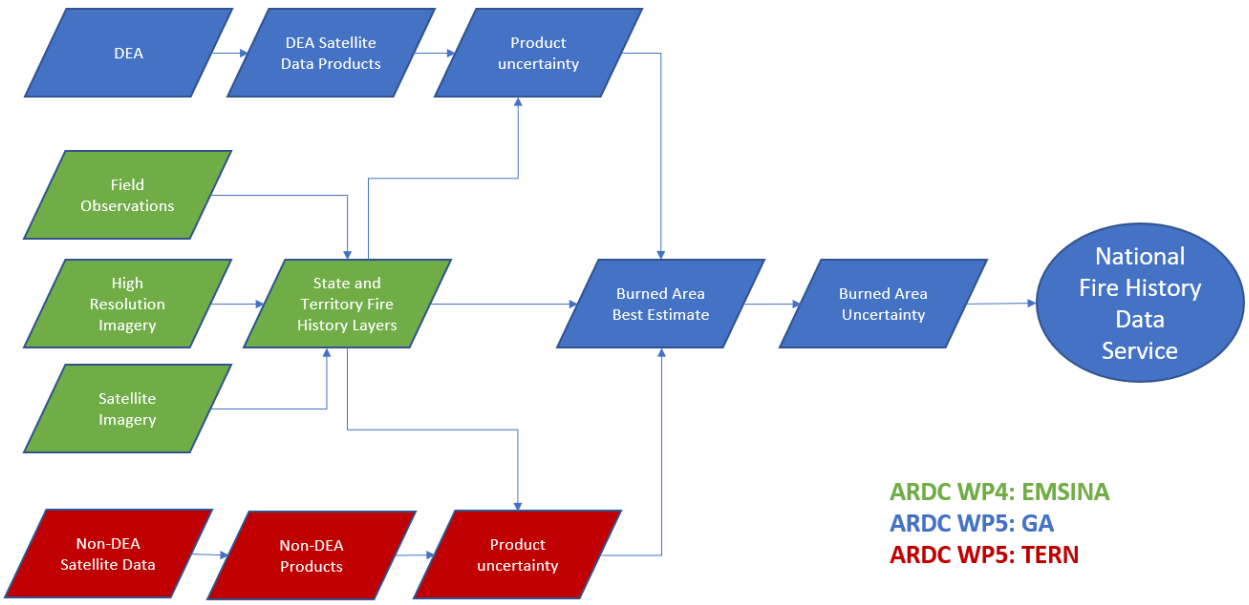

Figure 1: Flowchart showing the integration of the ARDC Bushfire Data Challenge National Bushfire History project work packages.

The outputs of this information system will provide a benchmark for iterative improvement and development of national burnt area estimates, and help build understanding of fire impacts. Some potential applications for the data include:

- Inputs to estimates of current fire fuel parameters;
- Quantifying impacts on ecosystems and biodiversity for land managers;
- Understanding potential impacts on water quality or forecasting future catchment yields;
- Building an understanding of changes in fire regimes and links to land cover, population and climate changes.

The information system will also provide a valuable resource for researchers and the general public seeking to better understand the changing nature of bushfire impacting Australia.

2.1 Involvement

There are a number of groups involved with the delivery of this project, they are:

- The National Bushfire Intelligence Capability (NBIC) is a key future user of the bushfire history project outputs. The NBIC is building an information platform that would underpin decisions regarding investments in policies and programs to help build greater resilience to future threats of bushfires. Nationally consistent data from the bushfire history project will be used to help NBIC understand current fuel state, and to validate assessments of risk using the time series of burnt areas. Contingent on ongoing funding, NBIC will contribute 20% allocation for a remote sensing scientist and a scientific programmer to help implement WP5 mapping system.

3 Background

Based on an analysis undertaken in association with Digital Earth Australia's projects by Peter Stephenson (Appendix 2), there are several major stakeholder groups to consider: emergency management, planning, response and recovery; parks and wildlife, land owners or users, utilities, infrastructure, services, researchers, and the general public; national uses, such as carbon accounting, water management and quality, and environmental reporting of habitat stability and recovery. Emergency response groups are often most interested in a very rapid production of results that are better serviced by state based information systems. However, the National Bushfire History information system will have the potential for broader usage.

The report by Stephenson (Appendix 2) found that there were 15 high level requirements that users were interested in, the table from the report containing this information is reproduced below in Table 1.

Table 1. The high level requirements (HLR) of various users. Colours indicate: red - out of scope/not possible, orange - potential future work, yellow - potential stretch goal for this project, green - we already do or will in this project.

No.	Requirement	Description
HLR1	Access to Satellite Images as soon as possible.	Rapid Mapping / Processing of Satellite Images so they are available within hours of acquisition. Ideally within 30 minutes and preferably within 2-4 hours.
HLR2	Access to Polygon outlines of Burnt Areas / Flood Extents as soon as possible.	Automatic identification and definition of polygons which give the outline of Burnt Areas or Flood Extents as soon as possible after acquisition of the associated satellite image. Ideally within 30 minutes and preferably within 6 hours. The identification would be done via an automatic algorithm.
HLR3	Access to updated information when available	Access to interim data, both images and polygons, wher processing above th
HLR4	Checking availability of Rapid Mapping data for a specified location and when new data is expected to be available	Intuitive and interactive method of selecting a location and checking what data is available.
HLR5	Access to Final Processed Satellite Images when available.	Final Processed satellite images would replace the Rapid Mapping images when they become available.
HLR6	Access to Final Processed Polygon outlines of Burnt Areas / Flood Extents when available.	Polygons derived from Final Processed satellite images would replace the Rapid Mapping data when they become available.
HLR7	Indication of Cloud Cover during a satellite pass over a specified location.	An indication of the cloud cover when a satellite passes over an area of interest would be available to users.
HLR8	Notification of availability of Rapid Mapping data for a specified location.	Users would receive notification when the Rapid Mapping data for an area of interest they have specified is available for download.
HLR9	Notification of availability of Final Processed data for a specified location.	Users would receive notification when the Final Processed data for an area of interest they have specified is available for download.

HLR10	Pre-defined locations	Users can use pre-defined locations to obtain data. Examples of these locations are national parks, state forests or river catchment areas.
HLR11	Access to Historic Data of Burnt Areas / Flood Extents.	Users would be able to access historic data for Burnt Areas / Flood Extents.
HLR12	Reporting of Burnt Area / Flood Extent data.	Users would be able to view reports on the completeness, accuracy, latency and other aspects of Burnt Area and Flood Extent data.
HLR13	Retain data for an appropriate period of time	Disasters may be subject to inquiries and Royal Commissions. They may also be looked at via studies for planning. The data must be retained and be available for a period of time after the event.
HLR14	Data collection by methods which can penetrate cover	Users would like to be able to obtain data even if the area is covered by cloud or smoke. This would require the use of non-optical data.
HLR15	Files available for automatic download	The files should be placed in a location where they can be downloaded automatically by scripts from the Users.

There are several of the requirements listed above that are achievable and within the scope of this project. These are things like a web-based data portal so that users can view and download data when new data becomes available (HLR5&6).

Due to technical constraints (incl. data bandwidth and sensitivity limitations) for earth observation sensors there usually is a trade-off between spatial and temporal resolution. Figure 2 shows the temporal and spatial resolutions of various optical satellite based sensors suitable for burnt area mapping. Also indicated are the requirements of different applications of burnt area mapping.

This project **focuses on the use of Landsat 8/9 and Sentinel 2.** These sensors are well suited to strategic decisions where some latency is acceptable, and for reporting. Such reporting might include bushfire impacts such as properties destroyed, ecosystem damage and biodiversity loss, potential impacts on catchments and water yields and carbon emissions. Reporting also has the highest demand for consistency nationally and over time which is one of the main objectives of this project**.**

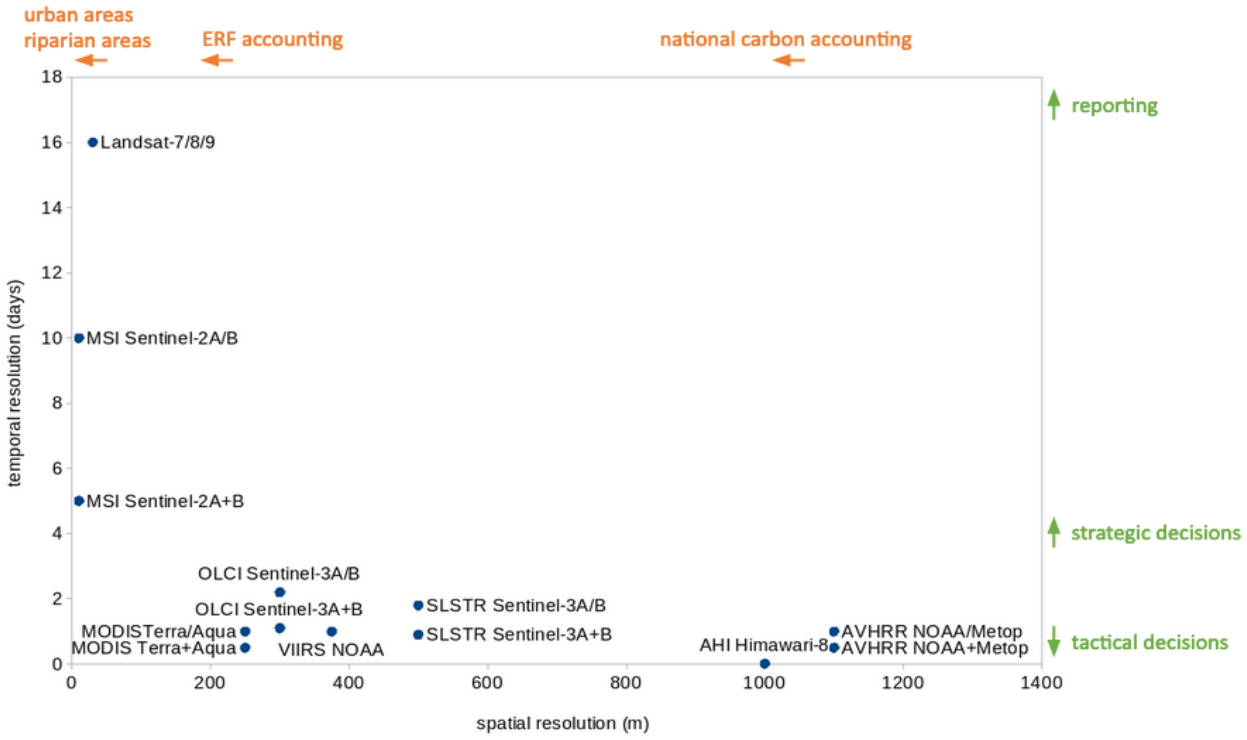

Figure 2. Temporal and spatial resolution of common optical satellite based sensors suitable for burnt area mapping in Australia. Points represent different sensors on various satellite platforms. Indicated along the axes are the requirements of different applications of burnt area mapping. The ARDC Bushfire History project will initially focus on use of sensors onboard the Sentinel-2 and Landsat 8/9 platforms.

GA manages satellite data archives going back to 1988, this archiving will continue, and this will support issues of data compliance as outlined in HLR11 and HLR13, however for this project we will have historic data for 10 years. It is envisaged that the burnt area data will be stored on a cloud platform, allowing users to access it for download via GIS and common scripting languages (HLR15).

The ARDC funded phase of this project will focus on optical satellite data. There will be no sensors used that are effective during cloudy conditions. However, GA has well established cloud detection and temporal mosaicking methods in place so the impact of cloud and smoke cover can be minimised (HLR14). Future iterations of the Digital Earth Australia (DEA) burnt area mapping system will likely consider other technologies such as synthetic aperture radar (SAR).

4 Burnt Area Mapping System Design

The ARDC Bushfire History project is designed to develop national information products describing the extent of burnt areas across Australia over time. The goal of WP5 of the project is to complement work being carried out by EMSINA to aggregate locally verified State and Territory Fire History data layers at national scale. This complementarity will be in two directions, by utilising these aggregated State and Territory data to quantify the confidence in remote sensing based burnt area data products, and to provide these data products back to States and Territories so that they can complement other data being integrated into their Fire History mapping. The system design is set out in the following section and is summarised in Figure 3.

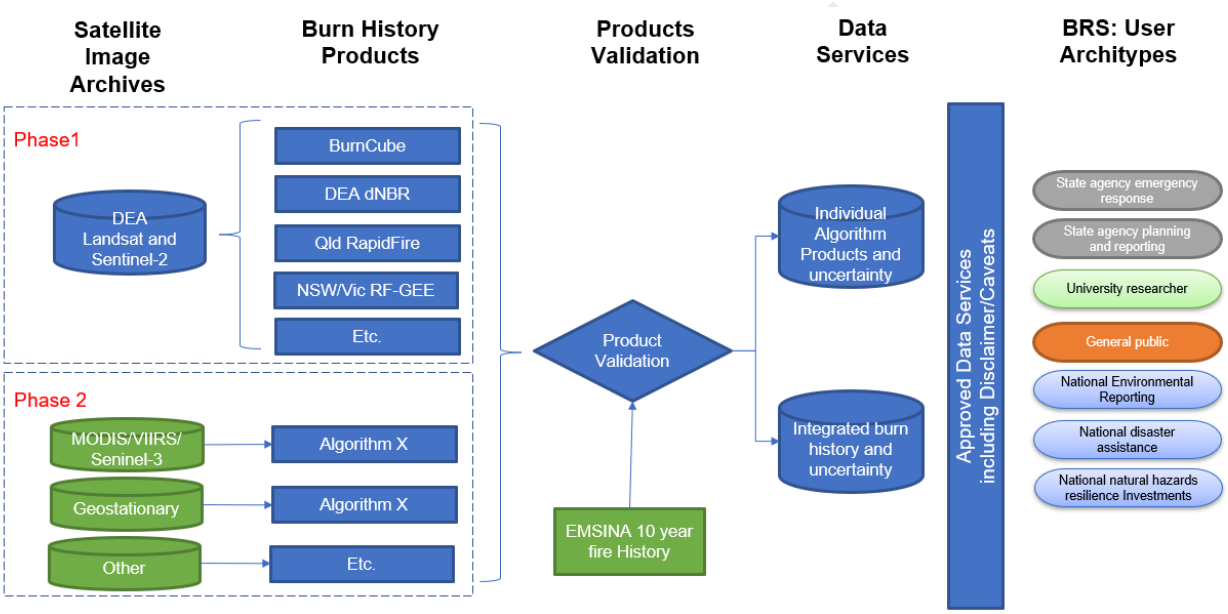

Figure 3: Proposed information flows and architecture for the national bushfire burnt area mapping system, along with some generalised user categories considered.

Minimum Viable Design Approach

The intention for the system implemented under WP5 is to become a demonstration of future capacity to deliver a burnt area mapping system. The system will be developed on the Digital Earth Australia (DEA) platform and exploit existing data pipelines, namely of Landsat and Sentinel-2 image data (see Figure 3, Phase 1). These data pipelines will initially be used to implement four existing burnt area algorithms. These algorithms will be a mix of research products (Landsat/Sentinel-2 integrated BurnCube and dNBR), and State based operational products (Qld RapidFire and Vic/NSW Random Forests models).

Output Product Specification

The National bushfire burnt area mapping system will provide a suite (**initially four**) of burnt area products. Each of these products will be delivered as a raster, on the same grid, with **30m** spatial resolution and a spatial extent covering all Australian territories excluding islands.

During phase 1 of the system implementation (ARDC project phase), product updates will be delivered on a **monthly** basis to allow minimisation of cloud effects, for **10 years** 2013-2023. Back processing of products to 1987 will occur prior to the completion of the ARDC project such that a full archive is made available to

end-users. No temporal processing of the time series will occur (e.g. Bayesian network etc), but could be considered in scope for future iterations of the system.

Deriving Uncertainty Layers

Each burnt area product will be delivered with a corresponding uncertainty layer. The development of these uncertainty layers will form a significant part of the overall project effort, and will consider:

1. Epistemic:
    1. Calibration Uncertainty: The distribution of calibration data used in model development.
    2. Typology Uncertainty: The land cover types represented within calibration and validation data.
2. Aleatory:
    1. Model Uncertainty: Internal algorithm-based uncertainty metrics.
    2. Validation Uncertainty: The relationship to available evidence, such as the relationship between satellite-based products and the past ten years of Fire History data, as provided by ARDC project WP4.

Data Services

Web Data Services will provide GIS and script-based access to both the burnt area product rasters and corresponding uncertainty rasters, after approval from the project steering committee, through the DEA platforms. The full time series of data will be made available via these services to streamline ingestion into State and Territory workflows. In addition to this service, data layers will also be made available via the DEA explorer graphical user interface (https://explorer.sandbox.dea.ga.gov.au/) so that end-users can browse and interrogate products online.

Approval and Consultation

Ongoing engagement with the project steering committee will include updates of the system implementation. When data is ready for release, the committee will be asked to provide final approval for public release of the data layers. Once approved the data will be released with a CC BY Attribution 4.0 International License to allow ongoing end-user testing and so that State and Territory agencies, and the research community can continue to develop algorithms and systems based on the data.

In the final phase of the project, and to ensure that the National Burnt Area Mapping System continues to develop and deliver on end-user expectation, GA will organise a Phase 1 delivery **workshop**, where representatives of key end-user groups will be asked to comment on the system adequacy and future development pathway.

Final Documentation

An algorithm theoretical basis, system design and user guide document will be produced for delivery at the final end-user workshop. This final document will be made available online and accessible via the DEA platform so that users understand the background, intent and limitation of the data provided, along with the most efficient ways to access and interact with the data.

5 Timeline

The project will proceed according to the following activity schedule, with reporting back to the project steering committee in December 2022, April 2023 and August 2023.

Activity	Jul 22	Aug 22	Sep 23	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Jul 23	Aug 23	Sep 23
Approach report completed															
BA model implementation															
Uncertainty method development															
BA model DEA integration															
Uncertainty DEA implementation															
Data Service implementation															
Steering comm. updates/approval															
Documentation															
End-user workshop															

6 Conclusions and Future work

The goal of the ARDC Bushfire Data Challenge, Burn History project WP5, is to develop a demonstration of a national system for the provision of burnt area mapping products. Initially four burnt area mapping algorithms will be implemented, each of which has its own strengths and limitations. It is not assumed that one method will be shown to work in all areas, or that a single integrated product will provide more accurate information than carefully audited state-based data. However, these new national products will supplement the information that is available to State and Territory agencies when they are reporting on areas impacted by bushfires, planning and investing in bushfire recovery, and in trying to understand current fuel conditions and residual bushfire risk.

In the development of any national information platform, it is important to consider the future development and sustainability of the system. Implementation of algorithms on Digital Earth Australia provides long-term stability for data product delivery.

Available data, and algorithms will change over time, and the system outlined above is designed to incorporate these developments as they occur. Key areas of focus for future development of the National Burnt Area Mapping System include:

1. Integration of additional data and algorithms: it should be acknowledged that there are many more potential burnt area mapping algorithms that could be implemented on the system. These have not been incorporated into phase 1 of the project as they require significant work in building pipelines for non-DEA satellite data. Early discussions are underway to determine if efficient automated data pipelines can be built across platforms to allow ingestion of products derived from low-resolution VIIRS and Himawari-8 satellite data, as well as SAR sensors. Prioritisation for integrating these products will be considered as part of the final workshop for this project.
2. The availability of low-latency products will help to increase the value of the National Burnt Area Mapping System. The integration of Landsat and Sentinel-2 data in each algorithm will help to bring down latency to between 5 and 16 days. However, as new satellite data pipelines are built into the system this may also help to bring down latency of products. This will be one consideration discussed as part of the final workshop for this project.
3. Temporal processing of the time series of burnt areas is likely to improve the accuracy of burnt area maps. Such a process would look across multiple time steps and determine if transitions between burnt and unburnt areas is reasonable. Established methods exist to perform such processing, and these would be considered during the final workshop.
4. Provision of burn severity data may assist fire and land management agencies to determine impacts, predict fuel re-accumulation and improve greenhouse gas emission estimates. Many algorithms being considered for burnt area mapping have some capacity to deliver an estimate of fire severity. However, the accuracy of these estimates across different sensors and over space and time is unknown. Future development of the system will evaluate the end-user benefits and accuracy limitations of providing fire severity data as part of the suite of data services.

Appendix A - Currently Available: What are the currently available Bushfire mapping algorithms and methods?

A.1 Within GA/DEA

A.1.1 BurnCube

BurnCube is a method to map burnt areas and is presented in Renzullo et al. 2019. The BurnCube uses DEA's archive of Landsat imagery, accessing it through the Open Data Cube. The method focuses on detecting deviations from the normal spectrum of a pixel in a time series (a spectral anomaly).

A geomedian is calculated from the previous five years of data (ideally), or fewer depending on the year and the detector being used, to find the deviation from the spectrum. To find this BurnCube uses the cosine similarity of reflectance spectra. A spectral anomaly is defined as the date when the distance is above a critical threshold, and when its neighbours in time space are also an anomaly.

Information on the specifics of the code can be found in the paper and in the BurnCube Beginners guide. Currently BurnCube can only be used on Gadi.

BurnCube outputs netcdf files with 7 layers: cleaned, corroborate, duration, moderate, severe, severity and startdate. StartDate and Duration are to do with when the fire started and how long it burnt for. Corroborate is the hotspot data, which shows whether there were hotspots in the area (using a 4km radius around the hotspots). The Severe layer is calculated from everything with a Duration greater than 1. The Severity layer is calculated from the "sevindex", based on the outliers. Moderate is found with region growing, where Severe is the seed map and Startdates are also used. Cleaned is based on all of this, checking which pixels are connected and using that to tidy up the results, as well as taking into account which month the fire started in. In this document, the severity layer is the one that is displayed most.

A.1.2 DEA Hotspots https://hotspots.dea.ga.gov.au/

Digital Earth Australia Hotspots is a national bushfire monitoring system that provides timely information about hotspots to emergency service managers and critical infrastructure providers across Australia. Updated with new information every 10 minutes, the mapping system uses satellite sensors to detect areas producing high levels of infrared radiation (called Hotspots) accurately to allow users to identify potential fire locations with a possible risk to communities and property.

Please note the following limitations of detecting Hotspots from satellite sensors.

- At best, hotspots information is 17 minutes old (this is how long it takes to download and process data into hotspots after each satellite pass)
- The Himawari-8 satellite is a geostationary satellite, which covers Australia at all times, and provides updates every 10 minutes, however the information is not published in real time and at best, is 17 minutes old.
- For all other satellites, they pass over a given area between 2 to no more than 4 times a day, and each pass covers only a part of Australia, which means some fires are not detected because the satellite was not looking over that particular area.

- The hotspot location on any map (no matter how detailed) is only accurate to at best 1.5 km
- The size of the hotspot does not indicate the area of fire
- Not all hotspots are fires; they can also indicate black soil, gas fires, industry, furnaces, smoke plumes or hot rocks
- Not all hotspots are detected by the satellites. Some heat sources may be too small, not hot enough, or obscured by thick smoke or cloud. E.g. under ideal conditions (Nadir view, no clouds) for MODIS the active fire area (flames) within a pixel has to be at least $100m^2$ to be detected (Maier et al. 2013).

Fire and Emergency Service Agencies requiring access to the registered layers should contact Geoscience Australia directly by email (earth.observation@ga.gov.au) for access details.

A.1.3 ACS Burn Mapping

The Burnt Area mapping method used for the ACS project uses NBR, NDVI and BSI to determine if an area is burnt. If NBR and either NDVI or BSI are above a certain threshold then it is classified as a burn. The barest Earth product is used as a summary to take differences from and as such any fire measurement is conservative. Once the area is located it is converted into a polygon to be used elsewhere.

Appendix B - Business analyst report (relevant sections):Burnt Area / Flood Extent Rapid Mapping

Business Requirement Document

Draft

Peter Stephenson

30 June 2021

B.1 Executive Summary

This report gives the business requirements which have been identified for the Burnt Area / Flood Extent Rapid Mapping project.

The main objectives of this project are:

- Satellite images from the Sentinel and Landsat satellites will be processed as soon as possible after the data is received. This will provide images within a few hours of data acquisition. To support faster processing not all the corrections used in normal processing will be applied. The images produced may not be as accurate but they will be available much sooner. The processing is expected to take a few hours so the images will be available the same day.
- In addition, the images will be processed to produce polygons giving the extent of the Burnt Area or Water (Flood) Extent at the time the image was taken. Previously this has been done manually when requested during emergencies. Under the proposal, the polygons will be generated automatically using an algorithm which analyses the spectral signatures in the images. It is expected that the processing for Burnt Areas and Flood Extents will be similar, although with different algorithms.

Stakeholders were identified and contacted to take part in and provide input into the development of these requirements. This consultation process included an online survey and virtual workshops between stakeholders and DEA / GA.

A number of common requirements were identified. These covered mainly technical issues relating to the implementation.

Fifteen (15) specific user requirements were identified. These have been described in user stores.

Future considerations have also been identified and described. These considerations include a review of the products after they have been implemented and been in use for a period of time.

B.2 Project Overview

B.2.1 Burnt Area / Flood Extent Rapid Mapping

Digital Earth Australia (DEA) obtains satellite data and provides the associated images and spatial data for use by government, industry and other users. The data reveals physical changes across Australia, supporting a range of uses such as water observations.

DEA works closely with other organisations to meet their needs. This includes Emergency Management and Emergency Response organisations.

Examples of current DEA offerings are:

- Satellite images
- DEA Hotspots
- Water Observations

During emergencies DEA has responded by providing additional information as required or requested. This has included providing data in a timely manner. The data and processes are not available routinely. They must be requested and activated in response to an emergency.

In response to recent disasters two initiatives have been identified to support the emergency management and response efforts across Australia. These initiatives are aimed at providing timely information about Burnt Areas and Flood Extents. These initiatives are being referred to as **Rapid Mapping**. Similar data has been referred to as Near Real Time.

B.2.1.1 Objectives

The main objectives of this project are:

- Satellite images from the Sentinel and Landsat satellites will be processed as soon as possible after the data is received. This will provide images within a few hours of data acquisition. To support faster processing not all the corrections used in normal processing will be applied. The images produced may not be as accurate but they will be available much sooner. The processing is expected to take a few hours so the images will be available the same day.
- In addition, the images will be processed to produce polygons giving the extent of the Burnt Area or Water (Flood) Extent at the time the image was taken. Previously this has been done manually when requested during emergencies. Under the proposal, the polygons will be generated automatically using an algorithm which analyses the spectral signatures in the images. It is expected that the processing for Burnt Areas and Flood Extents will be similar, although with different algorithms.

B.2.1.2 Expected Business Outcome

The Rapid Mapping aspect of these initiatives are aimed at providing timely data during the management and response phases of an emergency. It is expected that key users such as Emergency Management Australia (EMA), National Resilience Risk and Recovery Agency (NRRRA) and the State Emergency Services will access the data and incorporate it into their systems to make informed decisions on the management of emergencies and associated response.

The automatic generation of Burnt Area and Flood Extent polygons will provide data which can be used by a large range of users. These include Disaster Recovery, Emergency Planning and Research as well as Emergency Management and Response.

It is expected that the number and variety of users of the data will increase as the awareness of its availability and the amount of data increases.

B.2.1.3 User Characteristics

The Rapid Mapping information has applications for a large range of users. They can be divided into a number of groups or roles. The most important ones are listed below:

- Emergency Management
- Emergency Response
- Disaster Recovery
- Emergency Planning

Other user groups include:

- Parks and Wildlife
- Land Owners / Users
- Utilities
- Infrastructure
- Services
- Researchers
- General public

Most of the users who responded to this round of requirements gathering have been from the Emergency Management / Emergency Response areas. There were representatives from a number of the other groups as well.

It can be expected that Emergency Management, Emergency Response and Disaster Recovery will be early adopters. It can also be assumed that they have experience in satellite data, GIS packages and spatial data, i.e. expert users. They can be expected to be able to work with the files and data without much assistance.

Other users may not have as much expertise. If other users start to use the products they may require more assistance. The data may need to be "packaged" more before it is downloaded. This may involve cropping or combining images or files.

It is recommended that a review of the products be conducted after they have been available for a while. This review should aim to include more user groups.

B.3 Stakeholder Requirements

B.3.1 High-level Requirement (HLR)

No.	Requirement	Description	User story associated
HLR1	Access to Satellite Images as soon as possible.	Rapid Mapping / Processing of Satellite Images so they are available within hours of acquisition. Ideally within 30 minutes and preferably within 2-4 hours.	US1
HLR2	Access to Polygon outlines of Burnt Areas / Flood Extents as soon as possible.	Automatic identification and definition of polygons which give the outline of Burnt Areas or Flood Extents as soon as possible after acquisition of the associated satellite image. Ideally within 30 minutes and preferably within 6 hours.	US2

		The identification would be done via an automatic algorithm.		
HLR3	Access to updated information when available	Access to interim data, both images and polygons, when it is available. Interim data would reflect additional processing above the Rapid Mapping data but not Final Processed data.	US3	
HLR4	Checking availability of Rapid Mapping data for a specified location and when new data is expected to be available	Intuitive and interactive method of selecting a location and checking what data is available.		US4
HLR5	Access to Final Processed Satellite Images when available.	Final Processed satellite images would replace the Rapid Mapping images when they become available.	US5	
HLR6	Access to Final Processed Polygon outlines of Burnt Areas / Flood Extents when available.	Polygons derived from Final Processed satellite images would replace the Rapid Mapping data when they become available.		US6
HLR7	Indication of Cloud Cover during a satellite pass over a specified location.	An indication of the cloud cover when a satellite passes over an area of interest would be available to users.	US7	
HLR8	Notification of availability of Rapid Mapping data for a specified location.	Users would receive notification when the Rapid Mapping data for an area of interest they have specified is available for download.		US8
HLR9	Notification of availability of Final Processed data for a specified location.	Users would receive notification when the Final Processed data for an area of interest they have specified is available for download.	US9	
HLR10	Pre-defined locations	Users can use pre-defined locations to obtain data. Examples of these locations are national parks, state forests or river catchment areas.		US10
HLR11	Access to Historic Data of Burnt Areas / Flood Extents.	Users would be able to access historic data for Burnt Areas / Flood Extents.	US11	
HLR12	Reporting of Burnt Area / Flood Extent data.	Users would be able to view reports on the completeness, accuracy, latency and other aspects of Burnt Area and Flood Extent data.		US12

HLR13	Retain data for an appropriate period of time	Disasters may be subject to inquiries and Royal Commissions. They may also be looked at via studies for planning. The data must be retained and be available for a period of time after the event.	US13
HLR14	Data collection by methods which can penetrate cover	Users would like to be able to obtain data even if the area is covered by cloud or smoke. This would require the use on non-optical data collection.	US14
HLR15	Files available for automatic download	The files should be placed in a location where they can be downloaded automatically by scripts from the Users.	US15

B.3.2 User stories

B.3.2.1 US1 – Access to Satellite Images as soon as possible.

Burnt Area Usage

I am the on-duty manager in charge of the response centre coordinating the response to a bush fire emergency. Getting information quickly allows me to plan ahead and allocate resources accordingly. Members of the team obtain information from a range of sources and combine them together to give a view of the overall emergency.

When they are available Satellite images provide valuable information over a large area. The images may be available when it is not possible to organise a plane and obtain aerial photos.

However we require information as soon as possible, particularly for a rapid moving fire. If there is a trade-off between accuracy and timeliness we can work with less accurate data if it is available quickly. This is particularly the case if more accurate data will be available later.

Ideally we would like the satellite images to be available within 30 minutes of acquisition. However if the images were delayed 2-4 hours they would still be useful. After 6-12 hours the images would not be as useful, although this may depend on the particular circumstances of the fire.

The longer the data is delayed the less useful it is for active fire management but it is still useful to confirm other data.

I instruct the staff looking after the data and GIS systems to check regularly for satellite images and download them as soon as they are available.

B.3.2.2 US2 – Access to Polygon outlines of Burnt Areas / Flood Extents as soon as possible.

Burnt Area Usage

I am a Fire Services Supervisor. I am working in a response centre in charge of allocating fire crews to areas of the fire. Two new crews are available. I need to know the current extent of the Burnt Area so I can direct them to the most appropriate, and safe, location.

I check with the GIS specialist who informs me some satellite data giving the burnt areas has just become available. He goes to the DEA website and selects the area we are dealing with. A popup screen shows the available data. We check the time and date of the data and look at a quick preview. The data looks good.

He downloads the file and loads the data into our system. We overlay the burnt area polygons onto our cadastral and topographic maps. This shows us the current location of the fire fronts. Based on this information I instruct the crews which routes to take and what areas they will be responsible for.

B.3.2.3 US3 – Access to updated information when it is available.

Burnt Area Usage

I am coordinating the response to a fire in a largely inaccessible area. We do not have a good idea of the size and extent of the file. We downloaded the Rapid Mapping files from the DEA website a couple of days ago. It has given us some idea of the extent of the fire. As the fire is about to reach the boundaries of the area I would like to know the best spots to position the fire crews.

My GIS coordinator checked the DEA website and informs me that a more accurate set of data is available. I ask them to download it and load it into our system.

After analysing the new data we dispatch the fire crews to their assigned locations with more confidence.

B.3.2.4 US4 – Checking availability of Rapid Mapping data for a specified location and when new data is expected to be available.

A fire is burning in an area I am looking after. It is difficult to access the area but I need to know what is happening. I would like to find out what information is available. I go to the DEA website and look up the Rapid Mapping page. A map of Australia is displayed with the satellite paths overlaid. I zoom and pan to the area I am interested in.

I click on the map and a pop-up screen appears listing the last few satellites which have passed over the area. The screen shows the time of the pass, the % cloud cover at the time and the % confidence in the data. This lets me see if the data may be useful. The latest pass looks good. I click on a link to download the files.

I would also like to know when the next satellite passes are expected. I click on a tab on the screen. The table changes to display the next set of satellite passes. I notice that the next pass is due tomorrow morning. I make a note to check again tomorrow.

B.3.2.5 US5 – Access to Final Processed Satellite Images when available.

Burnt Area Usage

I am working for Emergency Services doing an initial assessment of the damage and areas affected by a recent bushfire. I have looked through the Rapid Mapping data which has given me a good starting point. I require accurate information and need access to final processed images.

I go to the DEA website and pan / zoom to the area I am looking at. A popup screen shows me what images are available. I find the files I am interested in based on dates. I download them and incorporated them with data I have from other sources.

I would like the images to remain available as I may need to compare them to images over the same area taken at a later date. This may be required for recovery comparisons.

B.3.2.6 US6 – Access to Final Processed Polygon outlines of Burnt Areas / Flood Extents when available

Burnt Area Usage

I am working for Parks and Wildlife. A fire has passed through one of the national parks we manage. The park is currently closed and we need to assess the damage and make the area safe before the park can be re-opened. I need an accurate indication of the burnt area.

I go to the DEA website and navigate to the national park. A popup screen shows me the polygon files which are available. Based on the time of acquisition of the files I select the one which will give me the best outline of the burnt area.

I download the file and incorporate it with the topographic maps we use. I determine which areas will be assessed by the various teams. I then distribute the maps to the teams along with their instructions.

B.3.2.7 US7 – Indication of Cloud Cover during a satellite pass over a specified location.

I am the on-duty emergency manager working in a response room handling an active fire. I have checked and know that a satellite will be passing over the area this morning, but there is considerable cloud cover. I would like to know if the data may be useful or if I may need to make other arrangements, e.g. an aircraft or drone.

A little while after the time of the satellite pass I log onto the DEA website. I use the map interface to pan and zoom to the area of interest. I click on the map once I have navigated to the location of the fire. A pop-up screen appears listing the last 5 satellite passes over the area. The % cloud cover is one of the data items listed.

I see that the cloud cover for the image was estimated to be 30%. I consider this acceptable and ask one of the team members to check when the data is available. I factor this into my plans and decide that organising a plane is not required.

B.3.2.8 US8 – Notification of availability of Rapid Mapping data for a specified location.

I am a GIS specialist managing the data for a fire emergency response. Part of my role is to make sure all the available data is as up to date as possible. I would like to know when new satellite data is available so I can assess it and incorporate it with information from other sources.

I go to the DEA website. I open the map showing the satellite paths. I pan and zoom to the area I am interested in. I click on it and select an option to be notified of new data. I enter an email address for my organisation.

A couple of days later I receive an email notifying me that some new data is available. I follow the link to the DEA website and download the files. I load them into our GIS. I follow the same process for satellite images and polygon files.

Over the next few days I receive emails when new data is available. I follow the link and download the data if necessary.

Once the emergency has passed I no longer wish to receive notifications. I click on an unsubscribe button on the email. I am directed to a page which asks me if I want to unsubscribe from just this scene or all scenes. I select all scenes and click the button.

B.3.2.9 US9 – Notification of availability of Final Processed data for a specified location.

I am part of a disaster recovery team. I am looking at the extent of a fire once it has been extinguished to see what properties have been affected as part of the disaster recovery process.

I go to the DEA website. I open the map showing the satellite paths. I pan and zoom to the area I am interested in. I click on it and a popup screen appears showing the available data. I notice there has not been data for some time. However a satellite pass has taken place around the time I am interested in. The processed data for this should be available soon. I select an option to be notified of new data. I enter an email address for my organisation.

A couple of days later I receive an email notifying me that some new data is available. I follow the link to the DEA website and download the files. I load them into our GIS. I follow the same process for satellite images and polygon files.

B.3.2.10 US10 – Pre-defined locations / areas of interest.

Burnt Area Usage

I am responsible for the data in a bushfire response centre. We are coordinating the response to a number of fires within a national park.

I go to the DEA website. I enter the name of the national park and a time period. A list of files associated with the park is displayed. I scan the list and select the most recent files. I download the files and load the data into our system.

B.3.2.11 US11 – Access to Historic Data of Burnt Areas / Flood Extents.

I am a university researcher looking at the dispersion of flood waters through a river catchment following major flood events. I require data on the extent of flood waters during particular floods. These extents should cover the period of the flood until the waters disperse. I also require extents of the water as it flows downstream.

I want to look at multiple flood event to make comparisons. I require historic data that extends over many years.

My research will be used in planning for future emergencies. It also provides input into future developments and the management of water within the catchment area.

I go to the DEA website. I pan and zoom the map to show the area I am interested in. Once I have selected the area a popup screen appears with a list of available files. I scroll through the list and select the files I require for download. I download the polygon files and associated images. These are accompanied by metadata.

The files are in a format which I can load into the GIS application I am using. I can also analyse them using scripting and programming languages.

B.3.2.12 US12 – Reporting of Burnt Area / Flood Extent data.

Short Time Frame Usage

I am managing the data in a central emergency control room. There are a number of fires burning and we are looking for the most up to date information.

I go to the DEA website to the reporting page. The table for recent data shows gives an indication of the processing times at various stages. The times indicate there may be delays.

I use the map interface to go to the overall area I am interested in. The data in the tables change. I notice there is a delay in the processing. The delay means the data will be of limited use. I note this and inform the controllers. We make plans accordingly, including contacting aerial survey companies.

Long Time Frame Usage

I am researching bushfires as part of an on-going fuel management project. I am looking to see what data is available and the reliability of the data. I am looking at the whole of Australia to start with.

I go to the DEA website then go to the reporting page. The tables on the page show me statistics for the overall data collection across Australia. This includes at least the following:

- Dates of acquisition
- Completeness
- Accuracy
- % obscured / cloud cover
- Latency
- Satellite details

I use the map of Australia to navigate to the area I am interested in initially. The tables update as I do.

I select an area and click on a button to show me all the files associated with the area. I note the dates of the files and accompanying information. The different satellites appear as separate items in the tables.

I enter the dates of one of the flood events I want to study. The list of files change. The accompanying data changes as well. I note that the completeness and accuracy indicate good data quality for most of the files.

I start selecting the files I need. I notice there are two files which show almost complete cloud cover. I leave them out of the selection. Once the selection is complete I download the files.

B.3.2.13 US13 – Retain data for an appropriate period of time.

Study

I am working in Emergency Planning. We have started a project looking at the way in which fires react to a variety of conditions including weather systems and fuel loadings. We have selected a small number of locations where there have been fires over a period of time. I require historical data going back over many fire seasons.

I go to the DEA website. I define the area(s) I am interested in via a polygon on the map interface. I obtain a list of the images and polygons available for the area. I select files for downloads based on the times of previous fires.

Some of the files are available immediately. I download these.

Some are not held online and must be requested. I submit a request for these. A few days later I receive an email saying they are available for download. I follow the link in the email and download the files.

I load the information into our systems and modelling software.

Inquiry

I am a data administrator working for NRRA. An inquiry has been announced into a recent flood. I have been asked to make sure all the data for the period of the flood is available.

I go to the DEA website. I define the area I am interested in. I obtain a list of the images and polygons for the area for the time period of the flood. I compare this with records of the data used during the emergency. I download the files to our system.

I notice some of the Rapid Mapping files which were used initially are no longer listed. I email the DEA contact to request these files. A few days later I receive an email saying they are available. I follow the link in the email and download the files.

I store the information on our network so it is available if required.

B.3.2.14 US14 – Data collection by methods which can penetrate cover.

I am working in a flood response centre. There has been thick cloud cover for many days. We have not been able to obtain any optical satellite or aerial data and have not been able to accurately map the flood extent.

A satellite is due to pass over the area today. We would like obtain radar images from the satellite to better plan our response to the flood.

B.3.2.15 US15 – Files available for automatic download.

I am working in the planning section of the state fire service. We are planning the fire reduction program for the coming months. We know we will require details of previously burnt areas so we can calculate fuel loads. A script has been set up to automatically download the Burnt Area files from the DEA website and put them onto our system.

These files are loaded into our system and combined with other information, such as rainfall, to predict regrowth, fuel loads and expected fire behaviour. Based on this information we develop a fuel reduction program using controlled fires and other methods.

B.4 Non-Functional Requirements

B.4.1 Look and Feel.

The system should be easy to use. It should be intuitive to navigate through the web pages. The data and file should be easy to locate. Any naming conventions should be clear and easy to understand.

B.4.2 Performance.

Users should not have to wait more than a few seconds for the response to queries to be displayed.

Download speeds will depend to a large extent on the speed of the user's connection however the system should be able to provide the data at an appropriate speed.

B.4.3 Scalability.

The system should be able to handle multiple users access the web pages and files at the same time. It can be expected that during an emergency

B.4.4 Availability.

The system should be available 24/7 with an uptime greater than 95%.

B.4.5 Capacity.

The system should have enough storage capacity to hold the expected files and data for at least two years worth of data.

B.4.6 Support and Maintenance.

The system should supported along with the rest of the DEA product offerings. Maintenance and upgrades should be performed during periods when usage is expected to be low, i.e. evenings or weekends.

Upgrades and outages should be suspended during emergencies.

B.4.7 Help / FAQs.

As users are external to DEA is it not possible to run training courses.

Help should be provided on the DEA web page. Pop-up tool tips should be implemented where appropriate.

A FAQ section should be provided on the web site. This should provide users with responses to common queries.

B.5 Review of Associated Studies / Initiatives

The circumstances which prompted the DEA Rapid Mapping initiative are not unique to DEA or Australia. While undertaking the requirements gathering a number of people make comments like:

> "Is this the same as XXX?"
>
> "Have you heard about YYY?"
>
> "It would be good to contact ZZZ."

Information from these other projects was reviewed and taken into account when developing these business requirements.

The most significant projects are discussed in the sections below:

B.5.1 Landgate (WA) Burnt Area Project

Landgate, Western Australian Land Administration Department, have been working on a project to automatically identify burnt areas / burn scars.

This work is being done on composite satellite images using an automated algorithm to classify the data in the image.

Not many of the requirements of the Landgate project are directly application to this project. However it would be useful to compare the operation of their algorithm with the DEA / GA developed algorithm.

It was noted in a meeting with Landgate that the characteristics of a burnt area in the open range, i.e. spinifex, areas of Western Australia are different to forest fires which are more common in the eastern states.

B.5.2 QLD Department of Environment and Science Burn Scars

This is an initiative to provide a historic record of Burn Scars within Queensland. An algorithm is being developed to identify the burn scars. The results are view manually and edited accordingly.

The data is historic and is released approximately a month after acquisition from the satellite.

Similar to the Landgate project it would be useful to compare the operation of the algorithm.

B.5.3 USGS Near Real Time Implementation

This is an initiative from the USGS to provide Near Real Time (NRT) satellite images. It is noted that these images can be used in a variety of emergency situations including fire, flood, oil spills and volcanic eruptions. The requirement for NRT data had been identified from users of Landsat data.

The USGS project has concentrated on the acquisition and processing of the data to an image and analysis ready stage. It is noted in the project documentation that algorithms to generate additional products, e.g. burnt areas, would be performed by user organisations.

The project has looked at streamlining the processing of data once acquired. It is noted that for fire and flood emergencies the data should ideally be available within 30 minutes but a 2 hour delay would be acceptable. This aligns with the requirements from the DEA investigations.

It may be useful to compare the USGS NRT processing with the DEA Rapid Mapping processing to determine if additional improvements can be made.

The USGS project also looked at the revisit rate for areas of interest. This can only be addressed by the commissioning of additional satellites.

Some details of the USGS project are given in Appendix G.

B.5.4 Artificial Intelligence for Earth Observation (AI4EO) Wildfires

This project is looking at using Machine Learning Algorithms to identify burnt areas. It is based on Copernicus Sentinel 2 data. It is only looking at wildfires / Burnt Areas / Burn Scars. It is not concerned with Flood Extent or provided Rapid Mapping data.

The information seen from this project describes the algorithm and its development rather than go into the end user requirements in details.

It would be useful to compare the algorithm from this project with the DEA developed algorithm.

Some details of the AI4EO project are given in Appendix H.

B.5.5 Requirements from previous work on Burnt Area Mapping

Some requirements were documented from previous work looking at Burnt Area Mapping. This has been included in Appendix I for reference.