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Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle

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Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle

Prepared for

National Institute for Forest Products Innovation

Mount Gambier

by

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Executive Summary

This report summarises the current situation with regard to fire detection and suppression systems in the Green Triangle region of South Australia and Western Victoria particularly as this relates to forest fires and the protection of plantation forestry assets. The report is provided as part of the larger NIFPI project NS034: Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle.

Key issues identified in the initial project workshop were:

- The importance of improved detection and speed of fire ignitions, within 5 minutes, including automated systems and risk based, cost effect early suppression response: working on the fire within 20 minutes of a detection.

Key issues identified relating to the current fire tower network were:

- For fire smoke column heights of 20m it was found by modelling that large areas weren't covered by the towers whereas once columns get to 50m only small areas of the region were not visible.
- Modelling indicated the overall robustness of the current fire tower network with removal of several towers not appreciably impacting visibility.
- Reducing the visibility distance to 15km significantly increased the areas visible from any tower.
- Increasing the height of a camera beyond that of the existing towers would improve coverage of the region.

Key issues identified relating to the use of UAVs project were:

- UAVs allow a level of coverage not available to ground based systems with an image resolution, cost and time benefit over traditional aircraft or satellites.
    - Local smaller UAVs that could take off from almost anywhere, have a flight time of up to 1 hour and would be deployed once a fire is detected to capture more information or perhaps apply some suppression.
    - Regional would be large UAVs that require a runway, can stay in the air for hours at a time and can monitor large areas.
    - Both these "types" of UAV have their advantages, but both are still currently limited in their application within Australia due to restrictions within governing legislation.
    - Integration of High-Altitude Pseudo-Satellite (HAPS), UAVs, both Aerial and Ground based, and sensor-based fire towers for the monitoring and possible suppression of forest fires is not too far away.

Key issues identified relating to the use satellite mounted cameras/sensors were:

- DEA Hotspots was identified to be the best existing freely available system suggested to Australia's forestry industry for space-based fire detection service. DEA Hotspots provides VIIRS - together with MODIS, AVHRR, and AHI derived fire hotspot information which can be easily integrated into a forestry company's GIS system. The biggest drawback of this system is that the underlying satellite sensor data still do not provide sufficient spatial, temporal and spectral resolution to detect small (note yet very hot) fires. Moreover, early detection is still far from less than an hour.
- Research into improving fire detection algorithms, including fire smoke detection and sensor fusion could help to further improve fire hotspot precision and location accuracy. Besides, cloud based deep learning could make use of big archives of satellite imagery data together with ground truthing confirming the real presence, location, extent and temperature of respective fire events and hence also improve early fire detection.
- Cube satellite constellations and HAPS provide very promising future solutions to significantly improve Space-based fire detection in the coming years. OroraTech and Airbus are pioneers, but we expect further companies to enter this competitive market soon as well.
- The most promising paid solution is OroraTech's WildFireSystem which will integrate stepwise during the next 4 years up to 100 nanosatellites which will open a new era of remote wildfire detection.
- Any of the above-mentioned space-based fire detection solutions will only operate well, when the area with a fire event is not covered by thick clouds. Hence, the best early fire detection system is a holistic one which would not only integrate space-based with terrestrial sensors/cameras, but also account for other fire reporting mechanism and fire risk information.

Key issues identified relating to the use of ground-based cameras/sensors were:

- Most of the latest forest fire detection techniques analyse video frame images for the colour and shape of smoke and flames, as well as their temporal behaviour.
- It is still a challenge to reliably identify smoke or flame because of their variability of shape, motion, transparency, colours and patterns.
- A lot of literature discusses efforts to increase detection accuracy and to reduce false positive classifications, but the detection time is also an important performance measure in a fire detection system.
- Fixed surveillance systems have the limitation that they can only monitor a limited area. To cover the areas not monitored by watchtowers, aerial detection systems and satellite image analysis can be used.

Key issues identified relating to the use of Phoenix Bushfire modelling were:

- The data used as a basis of the Phoenix Bushfire modelling contained many fires that occurred below the Very High fire danger rating. 2680 out of 3719 recorded ignitions occurred on days with peak FFDI below 25. These appear to have been easily suppressed with 111 reported fires resulting in 303 hectares reported as burnt.
- The probability of ignition surface used in this project assumes an average of 25 fires per year. This results in an estimate of losses consistent with the historical record.
- Modelled Average Annual Losses across both major species vary from about 600 to 900ha for detection times between 5 and 20 minutes.
- Modelling suggested that most of the losses will occur in the very high and severe fire danger ratings and very few in the Extreme to Code Red/Black Saturday FDRs.
- An increase in detection time leads to a significant increase in fire size and plantation impacts.
- The maximum area that could be lost from a single fire are broadly consistent with the losses on Ash Wednesday when 16,070 hectares of radiata pine plantation were lost.

Other areas of research undertaken in this project were:

- Review of contemporary fire detection methods, fleet dispatch travel model and fire risk management model.
- Discussion of fire management factors from an operations research point of view, including fire management methods, technology systems and strategic planning.
- Analysis of results of current fire risk management modelling and camera tower utilization technology applied in the Green Triangle.
- Development of a conceptual framework for an integrated smart fire suppression system including a GIS platform, a fire risk management model and a combined technology for a fire detection reporting system.

Table of Contents

Acronyms

AHI		Advanced Himawari Imager
AIIMS		Australian Inter-service Incident Management System
AVHRR		Advanced Very High Resolution Radiometer
CFA		Country Fire Authority (Victoria)
CFS		Country Fire Service (South Australia)
DEA		Digital Earth Australia
DEW		Department of Environment and Water (South Australia)
DELWP		Department of Environment, Land, Water and Planning (Victoria)
FFDI		Forest Fire Danger Index
FLIR		Forward-looking infrared
FOC		Forest Owners Conference
FWPA		Forest and Wood Products Australia Ltd
GIS		Geographic Information System
GPATS		Global Position and Tracking Systems Pty. Ltd.
GT		Green Triangle
GTRPC		Green Triangle Regional Plantation Committee
HAPS		High-Altitude Pseudo-Satellite
MODIS		Moderate Resolution Imaging Spectroradiometer
NIFPI		National Institute for Forest Products Innovation
SAGRN		South Australian Government Radio Network
UAV		Unmanned Aerial Vehicle
VIIRS		Visible Infrared Imaging Radiometer Suite

Introduction

The purpose of this report is to provide a basis for the development of a feasibility and cost benefit study aimed at innovative forest fire detection technological solutions and optimisation of forest fire controlling decision making processes. To do this efficiently what follows is a general description of the context in which plantation growers in the region operate, the current fire detection and suppression system and potential performance improvements. This sets the scene for the appendices which contain the work program arising from the steering committee, links to individual reports relevant to the areas of interest defined by the project steering committee and links to videos of the seminars run during the project:

- Appendix 1: Work Program for NIFPI NS034: Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle
- Appendix 2: Visibility of the Forestry plantation estate within the GT from its Fire Tower network; creation of a travel time dataset of suppression sources to ignition locations; use of UAVs with a focus on the limitations of current legislation in Australia. – Anthony Hay
- Appendix 3: Literature review of satellite mounted cameras/sensors – Stefan Peters
- Appendix 4: Literature review of Ground-based cameras/sensors – Jing Gao
- Appendix 5: Phoenix Bushfire Modelling - Quantification of the likely loss from bushfire under a range of fire scenarios and management actions – Owen Salkin
- Appendix 6: Fire Resource Suppression: Linking Fire Risk Management Models with smart fire detection technologies – Li Meng
- Appendix 7: Links to project-related seminars

Background

From a forest industry perspective, the Green Triangle is the second largest concentration of plantations nationally with 333,900 ha; 179,400 ha of softwood (radiata pine) and 154,400 ha of hardwood (Tasmanian bluegum). The plantations of the Green Triangle are of considerable value both to the industry participants and the economy of the of the region and the two States, South Australia and Victoria over which it spans, the industry's contribution to Gross regional Product being estimated at providing a $1,396 million and about 5,500 jobs are directly contributed. In summary, the high importance of the industry to the community, direct employees, contractors and supporting businesses and to the shareholders of the assets, it is not surprising that substantial investment can be justified to mitigating risks, the major risk in the region being fire.

The plantations are not the dominant land use in the Green Triangle but are concentrated in disparate geographic zones based mainly on suitable climatic and soil-based growing conditions. The spread of extent of plantations is approximately 260km east to west and 130km north to south, a spread of 3.4M hectares which is a large extend over which to detect and suppress fires. During the worst fire weather, the timeliness of fire detection and suppression has proven critical to loss minimisation, but it is recognised that under the highest risk fire danger conditions that the chances of containing a fire will be low. This is because fires can rapidly build to a size and intensity that cannot be contained by the suppression assets. In these circumstances there will be a reversion to the protection of human life and property such as houses. Firefighting tactics will concentrate on containment of potentially dangerous fire boundaries and later mopping up of fire damaged areas following passage of or extinguishment of the main fire.

A consideration of the current system requires an understanding of the climatic conditions and operating environment in the Green Triangle (GT) region to adequately assessing the risk of fire ignitions and their likely location, and when they occur the management responses to maximise the chances of loss minimisation. Loss minimisation is achieved by a combination of pre planning and fire preparation works and an efficient and effective fire detection and suppression system. All high fire risk regions have a combination of characteristics that may not be able to be modified, such as climate, which instead needs to be anticipated and monitored and characteristics which can be modified, such as fuels and hazards, which can some extent be mitigated, to overall ensure the extant fire detection and suppression arrangements are appropriate. The reality is that full risk reduction will not be feasible, and that communities and industries must be comfortable that fire risks have been managed to a defined and acceptable level.

Fire Weather

Located in the south east of the Australian continent, the Green Triangle is a Mediterranean climate characterised by a prolonged warm and sometimes hot, and dry summer season followed by a wet autumn and winter, and a predominantly spring growing season. The fire danger period is biased towards the summer and autumn seasons of the year (November through to April) caused by the coincidence of hot and dry climatic conditions and the passage of west to east moving cold fronts across the Australian continent. The incidence of the highest FFDI is recognised as being when strong, hot and dry north to north western winds occur followed by passage of a cold front and wind shift to the south west. Fires burning under catastrophic FFDIs, with enough flammable fuels in forest areas under these conditions, will burn on a long narrow front. Uncontrolled fires driven by a string south-westerly wind change will cause a much wider front as the eastern flank is pushed along by westerly winds. This was the fire behaviour exhibited during the 16 February 1983 fires where some 18,000 ha of plantations was burnt in an afternoon.

Fuels and Hazards

The nature of plantation fuels can be like those in the native forests which covered much of the Green Triangle region before European settlement. However, where the native forests were probably extensively managed by first nations people with frequent low intensity burning of understorey, the plantations are easily damaged by fire and therefore it must be excluded. In the early years of plantation growth, the flammability of plantation fuels is low, however, by the time the tree crowns are actively competing there is a continuum of fuel from the ground for the stem length which in the case of both major species planted can be up to 20m high by a plantation age of 20 years and be up to a maximum height of 35-40m at clear felling age. This can mean crown fires develop on bad days relatively quickly and in the absence of early intervention can become uncontrollable.

The fire behaviour of the two major species in the region is similar. However, Tasmanian blue gum plantations are generally planted at lower initial stockings and this can mean reduced fuel loads relative to radiata pine early in the plantation's life. Tasmanian bluegum has ribbon-type bark which may contribute to forward fire spotting, much like native eucalypt forest are susceptible.

Adjacent Land Uses

Most agricultural land uses that intersperse the plantation areas have lower fuel loads than plantation forest post canopy closure. Some irrigated crops will be unlikely to carry a fire and depending on the circumstances may even act as an effective firebreak to slow or halt a fire. Real-time or almost real-time knowledge of the fuel condition of adjacent land may assist with fire suppression activities. Some plantations have adjacent native forests, which if not having had recent fuel reduction treatment may be carrying high fuel loads and flammable and fire spotting vegetation types. Alternatively, recent and effective controlled burns in native forest will reduce overall fuel loads and reduce the understorey and the incidence of spotting due to fine fuels being carried ahead of the main fire.

Topography

Most of the topography of the Green Triangle is flat and it is rare in the region for topography to be a complicating factor in influencing either fire behaviour or by restricting suppression activities by limiting suppression access or other causes. However, there are some localities in the eastern part of the GT where river valleys may complicate suppression access and impacted on the location and quality of the road network. This may cause fire truck travel times to increase compared with those achievable in the South Australian side of the border.

Road Networks and Access

Most of the Green Triangle forest areas are accessible by at least fire tracks throughout the fire danger season with the only impediments being swamps and sandy soils. All front-line ground-based fire suppression equipment is at least 4WD capable and therefore capable of off-road access. Strategically located, sealed bitumen roads allow ground-based assets to be deployed efficiently. On days of high FFDI, where trucks are geographically dispersed across the GT, travel times for first arriving trucks to fires in forest areas can be as short as 15 minutes and no longer than 30 minutes.

Organisations

Overall responsibility for fires in South Australian rural areas lies with the Country Fire Service and in Victoria with the Country Fire Authority. Both agencies operate fire stations and suppression assets across rural areas of their respective states with a mixture of career and volunteer staff. Native vegetation fires in South Australia are suppressed by specialist career crews and equipment from the Department of Environment and Water and in Victoria by their equivalent the Department of Environment and Land, Water and Planning.

All these agencies use multiple methods to rigger responses to fires officially being activated in South Australia via Adelaide Fire via 000 or in Victoria by VicFire 000.

In Victoria plantation forest owners are required to maintain at least one fire unit per 1500 ha of land but for risk management reasons most companies operate more fire truck assets than this minimum. During fire responses these assets although they are not dispatched by the main fire agencies are at fires integrated into their management and control systems and structures.

Plantation managers and their contractors because of their operational requirements will normally have access to other equipment such as dozers, tractors and graders that are useful for fire suppression.

Forest Owners Conference

The FOC is a subcommittee of the Green Triangle Regional Plantation Committee (GTRPC), established following the Caroline Fire of 2 February 1979 following which a review identified the need for all parties with forest fire responsibilities to better coordinate the forest fire management activities. The FOC meets at least twice a year at different host venues and the roles of chair and secretary are rotated between members annually. Its membership is all forest managers in the GT plus CFS, CFA, DELWP and DEW.

The scope of the FOC is broad and adaptable to emerging issues requiring coordinated responses. Initiatives include a mutual support schedule for firefighting resources that operates at varying FFDIs or on request, funding of the forest owners map book, plantation design guidelines, training and equipment guidelines, heap burning guidelines, coordinated training courses, machinery operating procedures and testing.

Water Availability

The soils of the GT are predominantly sandy and there are few permanent water bodies in the South Australian side of the border suitable for supporting large scale air tankers. There are however numerous groundwater bores and other associated infrastructure designed to deliver rates of water flow suitable for filling ground-based fire trucks. Western Victoria does have some shallow freshwater lakes, but these are not all permanent. In general, the lack of large-scale water bodies has meant that the logistics of water supply to support ground and small airborne suppression systems is essential to effective fire control.

Fire Preparation

In South Australia plantation forest owners are subject to plantation design guidelines that aim to summarise the mandatory requirements along with forest industry practices that deliver appropriate environmental, social and economic outcomes, including those related to fire protection. In Victoria the Management guidelines for private native forests and plantations, are the equivalent.

These requirements include planning and regular maintenance of roads, tracks and firebreaks that are adequate for vehicle and fire truck access during fire events and compartment sizes that allow suppression activities to occur in all parts of plantations. Firebreaks are also designed to operate as anchor points for fire line construction and to break the continuum of tree crowns and fuels that would otherwise exist and to make control of going fires easier.

Fuel modified zones within plantations are established by some forest managers to reduce the incidence of crown fire, reduce fuel loads and therefore fire intensity near major roads. Where native forests are managed adjacent to plantations, these are usually subject to fuel modification activities such as prescribed burning or other works. Plantation companies will also reduce grass and other vegetation that would otherwise build up on roadsides and on infrequently used fire breaks adjacent to and within plantations. Various methods are used including slashing, ploughing, stock grazing and spraying to reduce perennial grasses in particular that can limit fire spread.

Current Fire Detection and Suppression System

The current fire detection and suppression is designed to operate within the operating environment described above and to protect the plantation assets and in doing so provide fire protection for the whole of the region's community.

Detection

The key detection methods rely on a network of human operated fire towers located across the GT. There are about 20 human operated towers in the GT, being distributed evenly either side of the State border. There are no cameras installed in the towers and no operational use of satellites for fire detection.

The towers in South Australia are managed by ForestrySA (7) and Green Triangle Forest Products (1). In South West Victoria, the towers are managed by DELWP (8) and Hancock Victorian Plantations (1). These towers report through hourly or as suspected fires are seen. The towers are occupied during the fire season or as otherwise necessary based on a risk-based roster.

All the SA towers report to a ForestrySA run fire control centre in Mount Gambier via the SA Government Radio Network (SAGRN). Where likely fires are detected they are reported to 000 the ADELAIDE Fire number. ADELAIDE fire manages dispatches of CFS assets including water bombers. Where the fire is determined to be in Victoria, the Vic fire number is called. ForestrySA may deploy its own assets depending on fire location. Other forest owners listen in to the SAGRN and may deploy if their own assets are at risk. Where the fire danger rating is above FFDI 35 the FOC undertake conference morning calls to establish the equipment availability and other arrangements for the day.

The Victorian towers report to the DELWP office at Heywood using the Victorian Emergency Radio network and Fires are entered into the Vic Fires system and resources deployed as necessary including CFA, DELWP and ForestrySA. The SA and Victorian tower networks do not officially coordinate their activities but each of the ForestrySA and DELWP offices do monitor radio traffic across both radio networks. However, the two networks operate on different channels on separate radio hardware. The tower networks are not coordinated in their occupation of towers either on a daily or fire season basis. However, on days of high FFDI the two networks are likely to operate on a consistent basis when they are most likely to be needed. Some ad hoc communication occurs with the towers due to local arrangements.

The ForestrySA towers are operated by a long term contractor while the DELWP ones are operated by staff. Operators are trained to report all potential smoke sightings even if they are not convinced, they have detected a fire. Raised dust from white metal roads, quarrying activity and crop harvesting can be causes of false positives but reporting is preferred to non-reporting especially on high FFDI days. The fire office takes responsibility for resolving or confirming fires, if necessary, by requesting closer inspections by field-based staff. Where a fire is confirmed office staff will request regular updates from towers on smoke characteristics such as colour or smoke column development, movement or decline.

Other methods of fire detection in the GT include:

- Forest owners hire a fixed wing spotter plane that can be deployed on a defined flight path across the GT on days of FFDI 35+. The plane is also useful for monitoring the development of going fires; providing suggestions on deployment of suppression resources; and for confirming fires already suspected.
- Subscription lightning tracker is used to identify potential lightning strike locations.
- Active patrolling by forest company employees.
- Reports from other fire suppression agencies e.g. CFS, CFA, DELWP, DEW, other forest companies; and
- Reports from the public.

Suppression Assets

Suppression assets are comprised of front-line trucks for fire line operations and support bulk water carriers to deliver water close to the fire line to keep the trucks supplied with water and operational for the maximum time. The fire trucks are usually modified commercial trucks carrying tanks with 3000 to 4000 litres of water and having a large cabin to accommodate standard crews of typically 4 fire fighters. A driver, a pump operator and 2 nozzle and hose operators. Trucks are fitted with live hose reels for rapid deployment on arrival at fires, and dead reels with multiple 30 metre interlocking hoses designed for extended 'house lays' within plantation compartments where fire truck access is not possible, desirable or necessary. Crews are trained regularly in hose lay deployment and nozzle operation to ensure safety and efficiency when deployed at fires. Supply tankers can carry up to 20,000 litres of water but more usually carry enough water to supply two trucks (about 8000 litres).

The forest owners' systems are specifically designed and their crews trained for forest fire fighting. This allows crews to operate safely within plantation areas under going fire conditions where this would not be possible for crews without this specialist training or equipment.

The importance of crew protection arose from the 5 April 1958 Wandilo fire when 8 Woods and Forests Department employees were killed when an out of control fire burnt over their bogged and immobile trucks when they were attempting a head on attack. Since this time all front-line trucks used by ForestrySA have been designed with crew survivability in burn overs as a mandatory design capability. The latest generation of Firekings commissioned by Forestry from 2004, include a specially designed cabin, window screens, water sprays and reciprocating air conditioning systems. The capital cost of these custom designed and manufactures trucks is approximately twice that of a modified commercial truck.

Human Resources and Training

All plantation owners maintain a pool of staff trained in fire responsibilities in addition to operational or other roles based on CFA and/or CFS standards. All staff involved in fires receive certified training appropriate to their role in the fire organisation. Depending on the company staff may have received additional certified incident management training in AIIMS roles such as Sector Commander and Incident Controller so that they are available to be deployed on request into multi party incident management teams locally, elsewhere in Australia or even internationally. For basic plantation firefighter level, companies apply CFS/CFA training standards for Rural Fire Fighting and CFS/CFA Plantation Fire Fighting 1 Training.

Automatic Despatch

The FOC have agreed on an automatic despatch system specific to geographic zones, and FFDI (based on the Mount Gambier and Hamilton FFDIs). This system identifies the number of slipons, tankers (firetrucks) and bulk water carriers that will respond from each forest manager in the event of a fire. The commitment being to the end of the first firefighting shift if necessary. Further deployment must be negotiated.

System Performance and Critical Success Factors

The performance of the fire management systems in the GT is predicated on rapid detection of fires and rapid response so that suppression resources arrive at the fire when the chances of successful control are maximised. In plantation fires the transition from a ground-based fire to a crown fire can often represents a critical stage of development after which control becomes more difficult or impossible. Water bombers quickly deploying to a fire and rapidly dropping several effective loads of water and foam can often slow the development of the fire and provide the opportunity for ground-based resources to arrive and when properly managed control the fire.

Several stages are critical to minimising the arrival time of suppression resources at fires.

Fire Detection and Accurate Location

The time of accurate fire detection and accurate location is critical to identifying where resources are to be deployed. Water bombers can reasonably be activated on high FFDI days on suspicion of a fire even if it is not confirmed. This is on the basis that given an approximate bearing and distance as a guide, once firebombers are airborne the fire will be rapidly located. Ground based suppression resources, essential for effective fire control, also need to be rapidly deployed, although constrained to road and track networks, and without the advantage of a higher view, they must plan their route to the fire to minimise travel time. Being an emergency vehicle and operating under the appropriate Acts, they can use emergency lights and sirens to clear traffic to further reduce travel times.

Navigation to fires and suppression planning is greatly assisted by the FOC funded and regularly updated fire map books and in South Australia sign posts marking physical assembly points. The aim with navigation is to find the fastest, safe route to a fire. In the case of aircraft this is usually a direct line, allowing for any topography or high structures such as towers or powerlines. For ground-based suppression equipment the most direct route may not be the fastest or safest as road and traffic conditions will determine maximum speeds, and in the vicinity of the fire smoke and/or risk of an unsafe approach near to an uncontrolled fire edge may determine the route taken. In the immediate vicinity of the fire road conditions maybe hazardous due to limited visibility because or smoke and multiple equipment moving in unpredictable ways.

Fire Suppression

The existing suppression system has a reliance on the use of several small fixed wing aircraft, funded by the Australian Government and controlled by the CFS and CFA, for initial attack and then follow up suppression using ground-based equipment owned and operated by the plantation managers. The availability of the aircraft is at the discretion of the CFS and CFA and cannot be assumed to be always available and one or even both may be reassigned to another region of South Australia or Victoria assessed as having higher value assets at higher risk on any day. It may also be that in extreme weather conditions it is unsafe for aircraft operation and they cannot be used for suppression. To be sure of aircraft availability it would be necessary for the FOC to fund its own plane/s and to recognise that in the worst conditions that aircraft may be unable to be operated.

Despite the issues raised above with aircraft availability there is potential to consider alternatives to the mix of aircraft and ground based equipment available to the FOC members as there may be more cost-effective mixes.

Constraints on Performance

Identification of the constraints on the performance of the fire management system will provide the basis for investigation of the most critical variables and those that can be controlled versus those that can't be. From this analysis the variables that can be controlled can be considered in this project and the subsequent analyses provide recommendations for alternative system settings or technology that will improve overall system performance. At a project workshop conducted on 26 June 2019 with the project participants the following constraints and variables on the performance of the system were identified:

- Fire detection – variable: time between ignition and confirmed detection called in by tower on SAGRN/Vic equivalent
- Fire location - variable: time to precise to location usually by tower cross bearings
- (Fire report call – variable time to 000 call)
- Despatch call – variable: time to make despatch call to plantation manager
- Suppression despatch – variable: time until plantation manager responds
- (Travel time aerial suppression – variable: travel time until first aerial suppression)
- Travel time ground suppression – variable: travel time until first attack suppression equipment deployed at fire
- Total number of ground suppression assets deployed at the fire – variable: total number of assets committed to fire

The path from fire detection to suppression is essentially linear and although complex improvements are likely to be able to be made. Essential to a continuous improvement process is the availability of data relating to each stage of the process which is only partially available from records generated in the process of fire detection and suppression.

Potential performance improvements

Fire Detection

It will likely to be possible to make incremental improvements to the current system within the constraints of what already exist but major improvements will require addition of a new system in whole or part. For this reason the workshop attendees identified several priority areas for investigation as a part of this project as shown in Table 1 below.

Table 1 Fire detection and decision-making technology: current and future – Workshop 26 June 2019

Fire detection and decision-making technology: current and future		
Sentinel (satellite + micro satellites)	Weather (gridded)	Drones
Comms towers	Fire spread modelling (Phoenix)	Vic Emergency apps
Public (000) and mobile phone	FLIR (AIG) Imaging	Ground crews
GPATS – Lightning detection	Live streaming (aircraft)	Community fire reports
Patrols (Ground and air)	Foresight/Forecast	High altitude drones
Himiwari (Met satellite)	Night time air ops	Cameras
Commercial aircraft	Fire towers (x7 +1 Vic)	Wind towers / sensors
CFS / CFA Communication network	Radio network	Text messages
Paging	Patrolling	Automatic Despatch system
F Ban		

For the purposes of investigation these areas for further investigation have been summarised as:

- Improvements in existing system
- Replacement or supplementing existing system with ground-based cameras/sensors
- Replacement or supplementing existing system with UAV mounted cameras/sensors
- Replacement or supplementing existing system with satellite mounted cameras/sensors

Fire Suppression

The existing suppression system has a reliance on the use of several small fixed wing aircraft, funded by the Australian Government and controlled by the CFS and CFA, for initial attack and then follow up suppression using ground-based equipment owned and operated by the plantation managers. The availability of the aircraft is at the discretion of the CFS and CFA and cannot be assumed to be always available and one or even both may be reassigned to another region of South Australia or Victoria assessed as having higher value assets at higher risk on any day. It may also be that in extreme weather conditions it is unsafe for aircraft operation and they cannot be used for suppression. To be sure of aircraft availability it would be necessary for the FOC to fund its own plane/s and to recognise that in the worst conditions that aircraft may be unable to be operated.

Despite the issues raised above with aircraft availability there is potential to consider alternatives to the mix of aircraft and ground based equipment available to the FOC members as there may be more cost-effective mixes.

Improvements in Existing System

The improvements in the existing system will be limited to increasing its efficiency to make better use of the resources already available. Generally, the improvements that could be made would be to: speed up the reporting and improve the precision of smoke sighting location and confirmation; minimising potential errors in location which delay fire response; minimising the time for despatch of suppression resources; provide a clear assembly location for suppression resources and an efficient and safe route description; and coordinate the standby of all suppression equipment and crews across to maximise (or at least improve) the effectiveness and coverage of resources. Recording and analysis of key performance detection and suppression indicators would provide the basis for a continuous improvement mechanism.

In terms of the detection system which is currently based on human observers in towers here are some potential improvements which could improve the timeliness of fire detections and reporting information to provide more clarity related to detections:

- Increased coordination of the SA and Victorian tower operations, communication and reporting systems to improve consistency.
- Coordinated training and health testing of SA and Victorian tower observers.
- Centralised fire detection report processing and improved smoke sighting plotting and location identification and description.
- Improved speed and consistency of communication of smoke sighting locations to those controlling suppression resources.
- Automated plotting of smoke sightings to maximise location precision and minimise errors.
- Identification of fire detection key performance indicators; timely recording and summary reporting of key performance indicators to support a continuous improvements system that is available to the FOC.
- With regard to the existing fire suppression systems here are some potential improvements:
  - Improved procedures for rapid reception and dissemination of smoke sighting locations to suppression crews.
  - Optimised route planning to ensure crews receive origin and destination specific directions with safety and efficiencies a priority.

- Precise destination definition and suppression asset to maximise efficiency in fire line deployment.

- Real time suppression asset location to assist with suppression planning and safety monitoring.

- Identification of fire suppression key performance indicators; timely recording and summary reporting of key performance indicators to support a continuous improvements system that is available to the FOC.

Efficiencies in the existing system may also be achieved by rationalising the number of towers. The cost and risks associated with running and maintaining manned towers across the region are not insignificant. It could be that a reduced number of towers in combination with the replacement of some manned towers with other sensors or technology would see an improvement of the efficiency of the system.

Work Program Outputs

The purpose of this report is to provide a basis for the development of a feasibility and cost benefit study aimed at innovative forest fire detection technological solutions and optimisation of forest fire controlling decision making processes. Having established the basis for the research activity the appendices contain the outputs of the work program including links to the recorded seminars. The title, description and summary of the key results from the outputs follows.

Appendix 1: Work Program for NIFPI NS034: Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle. This Appendix contains the documentation arising from the initial meetings and defines the research needs directed by the steering committee.

The key issues identified in the initial project workshop were:

- Improved detection and speed of fire ignitions (within 5 minutes), including
- automated systems and
- risk based, cost effect early suppression response (working on the fire within 20 minutes of a detection).

Appendix 2: Visibility of the Forestry plantation estate within the GT from its Fire Tower network; creation of a travel time dataset of suppression sources to ignition locations; use of UAVs with a focus on the limitations of current legislation in Australia. The chapters contained within this document represent the contributions made by Anthony Hay from Esk Mapping and GIS, formerly from Flying Ant GIS. The contribution is three part, firstly an investigation into the visibility of the Forestry plantation estate within the Green Triangle Region of South East Australia from its Fire Tower network. Second, the creation of a dataset of the travel time of suppression sources to an ignition location across the Green Triangle Region as an input into the Fire spread modelling. Lastly the use of Unmanned Aerial Vehicles (UAVs) is briefly discussed, with a focus on the limitations of current legislation in Australia.

The key issues identified were:

- For fire smoke column heights of 20m it was found by modelling that large areas weren't covered by the towers whereas once columns get to 50m only small areas of the region were not visible.
- Modelling indicated the overall robustness of the current fire tower network with removal of several towers not appreciably impacting visibility.
- Reducing the visibility distance to 15km significantly increased the areas visible from any tower.
- Increasing the height of a camera beyond that of the existing towers would improve coverage of the region.
- UAVs allow a level of coverage not available to ground based systems with an image resolution, cost and time benefit over traditional aircraft or satellites.
    - Local smaller UAVs that could take off from almost anywhere, have a flight time of up to 1 hour and would be deployed once a fire is detected to capture more information or perhaps apply some suppression.
    - Regional would be large UAVs that require a runway, can stay in the air for hours at a time and can monitor large areas.
    - Both these "types" of UAV have their advantages, but both are still currently limited in their application within Australia due to restrictions within governing legislation.
- Integration of High-Altitude Pseudo-Satellite (HAPS), UAVs, both Aerial and Ground based, and sensor-based fire towers for the monitoring and possible suppression of forest fires is not too far away.

Appendix 3: Literature review of satellite mounted cameras/sensors. Stefan Peters review has discussed available satellite sensors for fire detection as well as their limitations.

Key findings were:

- DEA Hotspots was identified to be the best existing freely available system suggested to Australia's forestry industry for space-based fire detection service. DEA Hotspots provides VIIRS- together with MODIS, AVHRR, and AHI derived fire hotspot information which can be easily integrated into a forestry company's GIS system.
- The biggest drawback of this system is that the underlying satellite sensor data still do not provide sufficient spatial, temporal and spectral resolution to detect small (note yet very hot) fires. Moreover, early detection is still far from less than an hour.
- Research into improving fire detection algorithms, including fire smoke detection and sensor fusion could help to further improve fire hotspot precision and location accuracy. Besides, cloud

based deep learning could make use of big archives of satellite imagery data together with ground truthing confirming the real presence, location, extent and temperature of respective fire events and hence also improve early fire detection.

- Cube satellite constellations and HAPS provide very promising future solutions to significantly improve Space-based fire detection in the coming years. OroraTech and Airbus are pioneers, but we expect further companies to enter this competitive market soon as well.
- The most promising paid solution is OroraTech's WildFireSystem which will integrate stepwise during the next 4 years up to 100 nanosatellites which will open a new era of remote wildfire detection.
- Any of the above-mentioned space-based fire detection solutions will only operate well, when the area with a fire event is not covered by thick clouds. Hence, the best early fire detection system is a holistic one which would not only integrate space-based with terrestrial sensors/cameras, but also account for other fire reporting mechanism and fire risk information.

Appendix 4: Literature review of Ground-based cameras/sensors. This appendix includes the work of Jing Gao and concluded that:

- Most of the latest forest fire detection techniques analyse video frame images for the colour and shape of smoke and flames, as well as their temporal behaviour.
- It is still a challenge to reliably identify smoke or flame because of their variability of shape, motion, transparency, colours and patterns.
- A lot of literature discusses efforts to increase detection accuracy and to reduce false positive classifications, but the detection time is also an important performance measure in a fire detection system.
- Fixed surveillance systems have the limitation that they can only monitor a limited area. To cover the areas not monitored by watchtowers, aerial detection systems and satellite image analysis can be used.

Appendix 5: Phoenix Bushfire Modelling - Quantification of the likely loss from bushfire under a range of fire scenarios and management actions. Owen Salkin's modelling work concluded that:

- The data used as abasis of the modelling contained many fires that occurred below the Very High fire danger rating. 2680 out of 3719 recorded ignitions occurred on days with peak FFDI below 25. These appear to have been easily suppressed with 111 reported fires resulting in 303 hectares reported as burnt.
- The probability of ignition surface used in this project assumes an average of 25 fires per year. This results in an estimate of losses consistent with the historical record.
- Modelled Average Annual Losses across both major species vary from about 600 to 900ha for detection times between 5 and 20 minutes.
- Modelling suggested that most of the losses will occur in the very high and severe fire danger ratings and very few in the Extreme to Code Red/Black Saturday FDRs.

- An increase in detection time leads to a significant increase in fire size and plantation impacts.
- The maximum area that could be lost from a single fire are broadly consistent with the losses on Ash Wednesday when 16,070 hectares of radiata pine plantation were lost.

Appendix 6: Fire Resource Suppression: Linking Fire Risk Management Models with smart fire detection technologies. – Li Meng

- Review of contemporary fire detection methods, fleet dispatch travel model and fire risk management model
- Discussion of fire management factors from an operations research point of view, including fire management methods, technology systems and strategic planning
- Analysis of results of current fire risk management modelling and camera tower utilization technology applied in the Green Triangle area
- Development of a conceptual framework for an integrated smart fire suppression system including a GIS platform, a fire risk management model and a combined technology for a fire detection reporting system

Appendix 1: Work Program for NIFPI NS034: Scoping an Automated Forest Fire Detection and Suppression Framework: Forest Fire Detection and Suppression System in the Green Triangle

Workplan – NIFPI NS034: Scoping an Automated Forest Fire Detection and Suppression Framework

Purpose

A feasibility and cost benefit study aimed at innovative forest fire detection technological solutions and optimisation of forest fire controlling decision making processes.

Premise

The major risk to the $2.2B forest industry in in the Green Triangle is the loss of substantial wood fibre resources caused by wildfire. For the protection of the plantation forest assets from fire, the industry is reliant on a network of manned towers for detection and a large fleet of mainly privately-owned suppression resources.

Outcomes of industry-researcher workshops 26-27 June 2019

Workshop attendees: Jim O'Hehir, Euan Ferguson, Adrian Lynch, Jing Gao, Duncan Cook, Chris Gibson, Anthony Hay, Stefan Peters, Michelle Chislett, Mike Lawson, Jeff Cownie, Gary Weir, Andrew Matheson, Natalie Said, Chris Medlin, Kevin Wilson, Greg Saunder, Ruth Ryan, Owen Salkin, Gordon Robson, Anthony Walsh, Andrew Moore, Darrien Schultz

Workshop attendees were asked the following questions and the results were scored and consolidated to provide a unified view:

1. What are your expectations of this project?
2. What technologies (Detection / Decision Making) do we currently use or are considering?
    a. Established?
    b. Consolidating?
    c. Emerging?
    a. Conceptual?
3. What are the risks – likelihood, consequence?
    a. The research project
    b. Implementation of findings

What are your expectations of the project?

The following expectations were identified and voted in descending order:

1.1.1.1. Improved detection of fire ignitions (incl extending timeframes) - 10 votes
1.1.1.2. Automated detection system – 8 votes
1.1.1.3. Real time - 6 votes
1.1.1.4. Identify essential criteria of best practice cost vs risk and loss ROI – 4 votes
1.1.1.5. Cost comparison with existing systems – 3 votes
1.1.1.6. Thinking around integration into existing/future Vic/SA systems – 2 votes
1.1.1.7. Interactive – interact with towers, between systems -2 votes
1.1.1.8. Early suppression response – 2 votes
1.1.1.9. Improved consequence reporting relating to fire starts – 2 votes
1.1.1.10. KI – 2 votes
1.1.1.11. 24 hours – 1 vote
1.1.1.12. Reduction in fake positives – 1 vote
1.1.1.13. Accurate – reduced false alarms – 1 vote
1.1.1.14. Fall back – robust – what happens if technology fails? – 1 vote

What technologies (Detection / Decision Making) do we currently use or are considering?

Workshop attendees were asked to list the following technologies that were: established, consolidating, emerging, conceptual.

Fire detection and decision-making technology: current and future		
Sentinel (satellite + micro satellites)	Weather (gridded)	Drones
Comms towers	Fire spread modelling (Phoenix)	Vic Emergency apps
Public (000) and mobile phone	FLIR (AIG) Imaging	Ground crews
GPATS – Lightning detection	Live streaming (aircraft)	Community fire reports
Patrols (Ground and air)	Foresight/Forecast	High altitude drones
Himiwari (Met satellite)	Night time air ops	Cameras
Commercial aircraft	Fire towers (x7 +1 Vic)	Wind towers / sensors
CFS / CFA Communication network	Radio network	Text messages
Paging	Patrolling	Automatic Despatch system

F Ban		

What are the risks – likelihood, consequence?

Workshop attendees were asked to identify risks that may need to be mitigated related to the project.

Risk	Likelihood	Consequence	Mitigation
Loss of project focus	High	Nothing useful is delivered	Clear directions to researchers on deliverables. Steering committee to maintain oversight of project
Tech solution can't deliver….yet!	High	Nothing useful is delivered	It would still be useful to identify over the horizon technology. The perfect solution will never be attainable, and compromise will be necessary.
Brilliant solution not supported by (risk averse) State agencies	Medium	Nothing useful is delivered	Engage state agencies closely to ensure understanding.
Solution too costly	Medium	Implementation delay or reduced capacity	The perfect solution will never be attainable, and compromise will be necessary.
Transfer of cost and responsibility from state to industry	High	Increased cost to industry	Engage state agencies closely to ensure understanding.
Short timeframes	Medium	Deliverables may not match expectations	Ensure at least some low hanging fruit is included in the project.
Information overload / Lack of focus	High	High	Clear directions to researchers on deliverables. Steering committee to maintain oversight of project
Change in direction / priorities	Medium	High	Clear directions to researchers on deliverables. Steering

Risk	Likelihood	Consequence	Mitigation
			committee to maintain oversight of project
Research priorities	Medium	High	Clear directions to researchers on deliverables. Steering committee to maintain oversight of project
Area of scope i.e. GT	High	Medium	Some consideration of transferability of findings. To cover KI will require a separate project to model the viewshed.
Budget Implementation	Low	High	The perfect solution will never be attainable, and compromise will be necessary.
Skills and ability to deliver	Medium	Medium	Clear directions to researchers on deliverables. Have ensured skills cover the required deliverables.
$ to implement	High	High	The perfect solution will never be attainable, and compromise will be necessary.
State's cohesion	High	High	Engage state agencies closely to ensure understanding.
$ or time aren't enough to reach viable, robust, operational outcome	Medium	High (no pay back for investment)	Clear directions to researchers on deliverables. Steering committee to maintain oversight of project
Disruptive technology replaces project	Low	Medium	This would be a good outcome but unlikely.
Collaboration = complication • Sub optimal outcome	High	High	Clear directions to researchers on deliverables. Steering

Risk	Likelihood	Consequence	Mitigation
			committee to maintain oversight of project.
Inadequate stakeholder engagement	Low	Medium	Steering committee to maintain oversight of project
Key people loss	Low	Medium	Ensure some overlap between researcher understanding.
Limited access to new tech/IP restrictions	Medium	Medium	The perfect solution will never be attainable, and compromise will be necessary.
New skill set commercialisation & support, ownership (of new system)	High	High	Probably out of scope for this project as relates to implementation.
Political will / funding (cost)	High	High	The perfect solution will never be attainable, and compromise will be necessary.
Delivery model / responsibility (for activity) state division	High	High	Engage state agencies closely to ensure understanding.

Steering Committee

Industry partners were asked to nominate potential members and to appoint a chair and deputy chair, the following were nominated:

> Justin Cook (OFO) – Chair, Mike Lawson (SFM) – Deputy Chair
>
> Ruth Ryan (HVP), Gary Weir (CFA), Jeff Cownie (Timberlands & FOC), Michelle Chislett (PFO), Laurie Hein (GTFP) – in absentia – will confirm, Chris Gibson (FSA), John Probert (CFS) – in absentia – will confirm, Gordon Robson (AKD)

Vision for Detection and Decision Systems

Workshop attendees were asked to identify their vision of where the GT forest industry would be with regard to its detection and decision-making systems by 2030.

Proposed System Vision - by 2030 our Detection / Decision Making Systems will:

- Detect fires reliably and advise the state response agencies automatically – measure detection / decision making systems will be fully automated using the latest technology and be able to pick up fire starts quickly
- **performance measure** is detection within 1-5 minutes of an ignition.
- Fire suppression assets will be automatically sent out and working on the fire
- **performance measure** working on the fire within 5-20 minutes of a start
- Predicted spread will inform suppression resource allocation and tactics
- **performance measure** is integrated cross border prediction system available
- Have a reliable and agreed funding arrangement for operation/repairs/upgrade

System to provide evidence based (modelled) decisions:

Detection

60 minutes---------------→-------------10 minutes (current)----------→1-5 minutes (aspire)-----------→30 seconds

Dispatch

30 minutes---------------→-------------10 minutes (current)----------→1-5 minutes (aspire)-----------→30 seconds

Resources begin on suppression

60 minutes---------------→-------------20 minutes (current)----------→5-20 minutes (aspire)-----------→5 minutes

Performance – Cost Matrix for Model Development

Scenarios		Current Cat/High	Current – alternative 1	Aspirational – alternative 1	Aspirational – alternative 2
Assets	Tower (human)	10/5	7	5	
	Tower (cameras)	0/0	10	20	
	Satellite sensors	0/0	0	1	
	spotter	1/0	0	0	
	trucks	70 /25	40	40	
	planes	4 /0	8	10	
	people	150/70	100	80	
Performance measures	Total Cost ($/day)				
	Detection	10 m	10 m	7 m	
	Dispatch	10 m	10 m	5	
	Resources begin on suppression	20 m	20 m	10 m	
	System Loss Consequence	100 ha loss/$30k	100 ha loss/$30k	80 ha loss/$25k	

Description of Individual Researcher Contributions (Research work plans)

Dr. Stefan Peters, School of NBE, UniSA

Contribution

My contribution to NS034 will be to investigate continuous, area-wide solutions for fire detection and monitoring through Satellite Remote Sensing. Specifically, I will focus on:

- Best practise of Satellite RS for fire detection and monitoring – current solutions
- Trends, upcoming solutions and 10-year outlook of Space based fire detection solutions

Moreover, I will contribute to team-based investigation of integrated systems including terrestrial, near-Earth and space-based solutions to detect and monitor (forest) fires inside plantations and of fires from outside forests that may burn into them.

Deliverables

SP1 - Literature review focusing on state-of-the-art of satellite-based fire detection and monitoring; satellite sensor assimilation; satellite-based flammability models. This will include a discussion about best practise of space-based fire detection and monitoring solutions, as well as an outlook on new satellite platforms and sensors. The review will also provide recommendations for how these space-based solutions can be applied to fire detection and suppression in forest plantations in SA/VIC.

Jing Gao

Focused on various fire detection methods (rather than satellite)

Contribution

Jing's contribution is his technology and data analytics expertise. He will work with the rest of research team to provide feasibility studies on various technologies and methods from the technical perspective including non-satellite detection systems. With respect to the advanced data modelling (e.g. machine learning), he will identify the data management issues (e.g. data collection, data quality) derived from data driven fire detection methods.

Deliverables:

JG1 - Literature review focusing on state-of-the-art non-satellite-based fire detection and monitoring.

JG2 - Provide technology feasibility study sections in the chosen methods (by other researchers).

JG3 - A list of data management issues for machine-learning based fire event detection algorithms.

Anthony Hay, Flying Ant GIS

Focused on systems and analysis and development

Contribution

Anthony's contribution to the project will be two-fold;

1. UAV Systems

AH1 - Provide an overview of utilising UAV systems to both replace and complement current spotter-based Fire Tower systems, focusing on the required asset and infrastructure as well as legislative requirements.

2. Spatial modelling / GIS services

AH2 - Provide GIS services to team members to assist in travel time and resource allocation data across the Green Triangle Estate

Owen Salkin, Natural Systems Analytics

Contribution

My contribution to NS034 will be to provide Phoenix modelling that considers ignition and weather likelihood. This will provide a platform for determining the bushfire impacts on plantations for a range of detection times, travel times and mixes of suppression resources.

Deliverables

- Build a Phoenix Monte Carlo modelling suite that considers ignition likelihood and weather likelihood
- This will require interrogation of Bureau of Meteorology AWS data to build the Monte Carlo Phoenix project
  AH2 - Further information regarding travel time, resource location will be required – this could be provided developed by other project members

  OS1 - Explore the relationship: Response time = detection time + travel time

  OS2 - Outputs could include a summary of likely asset losses under different resource level locality scenarios

- To be reviewed following first workshop

- Dependant on data availability – may need to be tailored to suit budget/data availability/contribution of other team members

Li Meng

Contribution: Li's contribution to project is to develop a suppression system that can help transfer detected fire information into Phoenix and using Research Operations method to indicate the process or procedure of fire management into resource suppression model.

Li also contribute to vulnerability accessibility model to support Owen in Phoenix system to build transport accessibility model

LM1 - Li will conduct literature review on:

- up-to-date Research Operation methodology,

- resources suppression model

- vulnerability accessibility model

LM/OS1 - The outcome will be a transport accessibility model in Phoenix (work with Owen) for a new function and a firefighting resources suppression model that provide procedures to help obtain sufficient information to support Mt Gambier forestry enterprises for a cost effective fire management.

Project Milestones

Milestone No:	Achievement Date	Milestone Description	Total Cost for Milestone ($)	NIFPI Payment for Milestone ($)
1	1-Jul-19	Project Initiation	20,000	20,000
2	1-Oct-19	Report - Existing detection and suppression system description and benchmarking existing system performance	40,000	40,000
3	1-Dec-19	Report - A review of potential fire detection methods and suppression systems	40,000	20,000
4	1-Feb-20	Report - A description of an optimised & fit for purpose matched fire detection & suppression system	40,000	20,000
5	31-Mar-20	Report - An implementation plan for an optimised fire detection & suppression system	10,539	0
		TOTAL	$150,539	$100,000

When	Who	Action	How does action contribute to the main goal?	Implementation issues?
Milestone 2 – 1 October 2019		Report - Existing detection and suppression system description and benchmarking existing system performance		
	Jim O'Hehir & Greg Saunder	Report - Existing detection and suppression system description and benchmarking existing system performance	Provides a basis for comparison of alternative systems with current system.	N/A
Milestone 3 - 1 December 2019		**Report - A review of potential fire detection methods and suppression systems**	Needs to include possibilities from the Table above: Fire detection and decision-making technology: current and future.	

	Stefan Peters	SP1 - Literature review focusing on state-of-the-art of satellite-based fire detection and monitoring; satellite sensor assimilation; satellite-based flammability models. This will include a discussion about best practise of space-based fire detection and monitoring solutions, as well as an outlook on new satellite platforms and sensors. The review will also provide recommendations for how these space-based solutions can be applied to fire detection and suppression in forest plantations in SA/VIC.	Provides a basis for future satellite based monitoring	
	Jing Gao	JG1 - Literature review focusing on state-of-the-art non-satellite-based fire detection and monitoring. JG2 - Provide technology feasibility study sections in the chosen methods (by other researchers). JG3 - A list of data management issues for machine-learning based fire event detection algorithms.	Provides a basis for future UAV and camera-based monitoring	
	Li Meng	LM1 - literature review on: • up-to-date Research Operation methodology, • resources suppression model • vulnerability accessibility model		

Milestone 4 - 1 February 2020		**Report - A description of an optimised & fit for purpose matched fire detection & suppression system**		
	Owen Salkin & Anthony Hay	AH2 - Further information regarding travel time, resource location will be required – this could be provided developed by other project members OS1 - Explore the relationship: Response time = detection time + travel time OS2 - Outputs could include a summary of likely asset losses under different resource level locality scenarios		
		The outcome will be a transport accessibility model in Phoenix (work with Owen) for a new function and a firefighting resources suppression model that provide procedures to help obtain sufficient information to support Mt Gambier forestry enterprises for a cost-effective fire management.		
	Anthony Hay	AH1 - Provide an overview of utilising UAV systems to both replace and complement current spotter-based Fire Tower systems, focusing on the required asset and infrastructure as well as legislative requirements. AH2 - Provide GIS services to team members to create travel time and resource allocation data across the Green Triangle Estate.		

Milestone 5 - 31 March 2020		**Report - An implementation plan for an optimised fire detection & suppression system**		
	Euan Ferguson, Jim O'Hehir, Greg Saunder - editors	Report - An implementation plan for an optimised fire detection & suppression system		

Appendix 2: Visibility of the Forestry plantation estate within the GT from its Fire Tower network; creation of a travel time dataset of suppression sources to ignition locations; use of UAVs with a focus on the limitations of current legislation in Australia. – Anthony Hay

https://mymailunisaedu-my.sharepoint.com/:f:/g/personal/ohehirjf_unisa_edu_au/En0l5pjXYjZFkvBBig6RJ9wBGKtxIX5NBShjRqsl4M34lA?e=95knnY

Appendix 3: Literature review of satellite mounted cameras/sensors – Stefan Peters

https://mymailunisaedu-my.sharepoint.com/:f:/g/personal/ohehirjf_unisa_edu_au/En0l5pjXYjZFkvBBig6RJ9wBGKtxIX5NBShjRqsl4M34lA?e=95knnY

Appendix 4: Literature review of Ground-based cameras/sensors – Jing Gao

https://mymailunisaedu-my.sharepoint.com/:f:/g/personal/ohehirjf_unisa_edu_au/En0l5pjXYjZFkvBBig6RJ9wBGKtxIX5NBShjRqsl4M34lA?e=95knnY

Appendix 5: Phoenix Bushfire Modelling - Quantification of the likely loss from bushfire under a range of fire scenarios and management actions – Owen Salkin

https://mymailunisaedu-
my.sharepoint.com/:f:/g/personal/ohehirjf_unisa_edu_au/En0l5pjXYjZFkvBBig6RJ9wBGKtxI
X5NBShjRqsl4M34lA?e=95knnY

Appendix 6: Fire Resource Suppression: Linking Fire Risk Management Models with smart fire detection technologies – Li Meng

https://mymailunisaedu-my.sharepoint.com/:f:/g/personal/ohehirjf_unisa_edu_au/En0l5pjXYjZFkvBBig6RJ9wBGKtxIX5NBShjRqsl4M34lA?e=95knnY

Appendix 7: Links to project-related seminars

1. 7 May - NIFPI Presentation - GT Fire Tower Viewshed Analysis - Anthony Hay – Esk Mapping - 23 attended. https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=aad505b8-7720-474d-951b-abb4004c3577
2. 28 May - NIFPI Presentation - State-of-the-art of satellite-based fire detection and monitoring; satellite sensor assimilation; satellite-based flammability models – Stefan Peters – UniSA – 24 attended. https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=78c6c2e7-a76c-4fed-a427-abc90037a38a
3. 4 June - NIFPI Presentation - Phoenix Fire Modelling Phoenix Bushfire Modelling - Quantifying the likely loss from bushfire under a range of fire scenarios and management actions – Owen Salkin - Natural Systems Analytics – 31 attended. https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=9135d9be-4e68-4d87-a705-abd000290fee
4. 16 September - NIFPI Presentation - OroraTech Update - Björn Stoffers – 36 attended https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=e9a89410-5bd5-4447-9ff5-ac38007945f6
5. 1 October - NIFPI Presentation: Grassland Curing Assessment – Combining Satellite Data with Ground Observations - Danielle Wright CFA – 18 attended https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=87eee22f-c1e3-4aaf-a2d2-ac47003d64e0
6. 1 October - GTFA Presentation: Fireball International Presentation - – 30 attended https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=cf666587-8dd6-4c13-a8dd-ac470085f376
7. 21 October - NIFPI Presentation - Drones - Utilising RPA's in Fire Management for Forestry - Troy Lowther - 3FBAerworx – 26 attended https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=60978bda-2bd7-4f2f-947a-ac5b001e9b7b
8. 27 October - NIFPI Presentation - Operational Use of Phoenix - Musa Kilinc – CFA – 26 attended https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=6ad302a6-4592-4a3b-b7ce-ac61001926a5
9. 17 December - NIFPI Presentation - Robotto - Operational Autonomous Wildfire Recognition and Analytics drone platform - Kenneth Geipel - 22 attendees https://unisa.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=48458d09-f5f6-46b2-91c1-ac920069075b