CODE OF PRACTICE

Agricultural Mobile Field Machinery with Autonomous Functions in Australia

GPA Grain Producers Australia

SPAA Society of Precision Agriculture AUSTRALIA

TMA TRACTOR AND MACHINERY ASSOCIATION OF AUSTRALIA

Disclaimer

The information contained in this publication is provided in good faith and is believed to be reliable and accurate at the time of publication. However, the information is provided on the basis that the reader will be solely responsible for assessing the information and its veracity and usefulness.

The authors shall in no way be liable, in negligence or howsoever, for any loss sustained or incurred by anyone relying on the information, even if such information is or turns out to be wrong, incomplete, out-of-date or misleading.

In this disclaimer:

Author(s) means every, agent, agency, and corporate body thereof and each employee or agent of any of them.

Information includes information, data, representations, advice, statements and opinions, expressly or implied set out in this publication.

Loss includes loss, damage, liability, cost, expense, illness and injury (including death).

Reference

2021, CODE OF PRACTICE Agricultural Mobile Field Machinery with Autonomous Functions in Australia, 40 pp.

ISBN: 978-0-646-83727-7

Further details about this publication which is also available in digital format (PDF) can be obtained by contacting:

Grain Producers Australia
Email: admin@grainproducers.com.au | Web: www.grainproducers.com.au

Tractor and Machinery Association of Australia
Email: info@tma.asn.au | Web: www.tma.asn.au

Society of Precision Agriculture Australia
Email: info@spaa.com.au | Web: www.spaa.com.au

Acknowledgements

This code of practice has been developed by Grain Producers Australia (GPA) in conjunction with the Tractor and Machinery Association (TMA) - with input from AGCO, CNH, John Deere, Kubota and Nufarm Croplands - and the Society of Precision Agriculture Australia (SPAA) with extensive industry consultation.

This code of practice has been developed with the support of the Western Australian, Department of Mines, Industry Regulation and Safety, with acknowledgement to the Department of Mines and Petroleum, Safe mobile autonomous mining in Western Australia – code of practice 2015.

Input was also received from Australian agricultural industry and global manufacturers during the public comment period.

Foreword

Basis for a code of practice

This code of practice has been developed to operate under the Safe Work Australia Model Work Health and Safety (WHS) law and regulation,[1] Australian and State government agricultural environment legislation and regulations[2] and the Agricultural and Veterinary Chemicals Code Act 1994 and supporting state government legislation and regulations.[3]

A code of practice is a practical guide to achieving the standards of occupational safety and health required under legislation. It applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following a code of practice would achieve compliance with the duties in the legislation in relation to the subject matter of the code. However, like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that may arise. Duty holders need to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates. Compliance with the legislation may be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than a code.

Scope and application

This code of practice will assist those involved with the use of mobile machinery with autonomous functions (including semi-autonomous where automated machine functions operate in autonomous mode) used in agricultural field operations to meet their legislative obligations for work health and safety under the Safe Work Australia Model Work Health and Safety (WHS) laws.

The Code of Practice Agricultural Mobile Field Machinery with Autonomous Functions in Australia is designed to provide guidance on:

- mobile machinery with semi-autonomous and autonomous functions used in agriculture field operations
- developing and evaluating safe work procedures for use of such machinery.

The code of practice does not apply to:

- areas of conventional (manual non-automated or partially automated) agricultural machinery already used in farming
- manned agricultural field machinery including manned aerial vehicles
- forestry equipment
- unmanned aerial vehicles (UAV's)
- remote controlled systems, but parts could be relevant to mobile tele-remote systems if they incorporate additional autonomous mode of functionality
- autonomous mode of functionality of a process or machine that moves on
  - fixed infrastructure such as grain driers or processors and irrigation equipment
  - a fixed base (e.g. processing robots)
  - consumer products.

1 https://www.safeworkaustralia.gov.au/law-and-regulation
2 https://www.environment.gov.au/about-us/legislation
3 https://apvma.gov.au/node/4131

Who should use this code of practice?

You should use this code of practice if you design, sell or purchase and use mobile agricultural machinery with autonomous functions in agricultural field operations. The code of practice may also be useful for farm supervisors, operations personnel, and safety and health representatives who need to understand the hazards associated with such machinery.

How to use this code of practice

The code of practice does not preclude any state or federal government regulatory or legislative requirements for farm operations and includes references to both mandatory and non-mandatory actions.

The words “must” or “requires” indicate that legal requirements exist which must be complied with. The word “should” indicates a recommended course of action.

Contents

1. Introduction

1.1 Aims

Farming with mobile machinery that has autonomous functions, like any agricultural activity, is hazardous with many inherent risks. When integrated with a manned farm operation, additional risks may be present beyond those recognised for conventional farming techniques.

The aims of this code of practice are to describe:

- a set of desired safety outcomes for use of mobile machinery with autonomous functions under the Safe Work Australia Model Work Health and Safety (WHS) laws.
- the variables to be considered to demonstrate that mobile machinery with autonomous functions is safe and performing as designed
- the role of the competent person in the hazard management process for use of mobile machinery with autonomous functions used in agricultural field operations
- the broader occupational health and safety requirements for operating in accordance with the Safe Work Australia Model Work Health and Safety (WHS) laws and regulations, Australian and State government agricultural environment legislation and regulations and the Agricultural and Veterinary Chemicals Code Act 1994 and supporting state government legislation and regulations.

The code of practice promotes a proactive approach to the introduction and operation of mobile machinery with autonomous functions to ensure the safe use of the technology. It also promotes continuing communication and consultation between designers, importers, distributors and owners.

The general duty of care applies to all stakeholders from design and construction, control centres, farm planning, commissioning of systems, implementation, operation and maintenance to achieve the desired safety outcomes for farm operations.

Note: The terms semi-autonomous or autonomous do not apply to remote controlled systems, but parts of the code of practice could be relevant to remote controlled systems if they incorporate additional automated functionality and operate in an autonomous mode.

Used with the permission of Croplands and Raven

1.2 Structure of this code of practice

Chapter 2 describes the risk-based approach to managing safety.

Chapter 3 summarises the requirements for information, instruction, training and supervision to ensure the safe operation of mobile machines with autonomous functions used in agricultural field operations.

Chapter 4 describes the requirements for general hazard control management. These themes are then developed further for farm planning and design (Chapter 5), system planning and design (Chapter 6), commissioning (Chapter 7), operational hazard control (Chapter 8) and maintenance (Chapter 9).

Chapter 10 covers emergency management requirements.

Appendix 1 lists the legislative provisions that apply to farming activities in general.

Appendix 2 lists Australian and International Standards and other guidance that may apply to mobile machinery with autonomous functions.

Appendix 3 provides a glossary of terms used in this code of practice.

Appendix 4 contains detailed information on farm project management planning and implementation (PMP).

Appendix 5 provides general guidance about matters to consider when introducing mobile machinery with autonomous functions to farming operations.

Appendix 6 provides examples of potential autonomous field equipment farming risks.

Appendix 7 lists incident reporting requirements.

Used with the permission of AGCO

1.3 Roles and responsibilities

There are four main groups involved in the introduction of mobile machinery with autonomous functions:

- Designers and manufacturers — those who design and manufacture machinery
- Importers – those who import machinery
- Distributors – those who sell, distribute and service machinery
- Owners and operators — those who own or use the machinery, including operators, contractors and maintainers.

The first group may comprise multiple parties, including original equipment manufacturers (OEMs), third party developers or principal employers.

Communication and cooperation are key to a successful operation. The roles and responsibilities of those involved should be defined and agreed upon by all parties.

While some roles and responsibilities have been assigned to certain stakeholders, it is noted that many are dependent on information supplied by another party. Circumstances unique to each operation may result in assignment of some of these roles and responsibilities differing from those outlined below.

Designers and Manufacturers

The responsibilities of designers and manufacturers should include:

- assessing farming operations and determining the suitability and compatibility of the machinery
- determining requirements for owner/operator supplied componentry, including functional safety requirements, that will allow the owner/operator to ensure integrity of final system (e.g. communications infrastructure)
- establishing performance specifications
- fulfilling the duties and obligations of designers and manufacturers as required by the Safe Work Australia Model Work Health and Safety (WHS) laws (Appendix 1)
- performing risk assessment
- compliance with current international ISO standards (Appendix 2)
- developing information and instructions that will accompany the machine with regard to:
  - safe operating procedures
  - residual risk
  - operation
  - operating parameters
  - maintenance
  - servicing
  - specifications
- providing assurance of certification-type testing of the machinery, systems and components (e.g. electromagnetic compatibility, telecommunications, etc.)
- monitoring field performance and incidents
- providing ongoing maintenance and service support for owners/operators
- participating in the development of standards to which the machine will comply

Importers

The responsibilities of importers should include:

- fulfilling the duties and obligations of an importer as required by the Safe Work Australia Model Work Health and Safety (WHS) laws (Appendix 1)
- compliance with current international ISO standards (Appendix 2)
- conveying to the distributor, owner or operator the following information, which is provided by the manufacturer:
  - safe operating procedures
  - residual risk
  - operation
  - operating parameters
  - maintenance
  - servicing
  - specifications
  - risk assessment information
- providing ongoing maintenance and service support for owners/operators

Distributors

The responsibilities of distributors should include:

- fulfilling the duties and obligations of a distributor as required by the Safe Work Australia Model Work Health and Safety (WHS) laws (Appendix 1)
- assessing farming operations and determining the suitability and compatibility of the machinery
- participating in site risk assessments to determine the suitability of the proposed machinery
- providing ongoing maintenance and service support for owners/operators
- conveying to the owner or operator the following information, which is provided by the manufacturer:
  - safe operating procedures
  - residual risk
  - operation
  - operating parameters
  - maintenance
  - servicing
  - specifications

Owners and Operators

The responsibilities of owners and operators should include:

- fulfilling the duties and obligations of an owner or operator as required by (Appendix 1):
  - Safe Work Australia Model Work Health and Safety (WHS) laws
  - legislation with the registered Agricultural Pesticides and Veterinary Medicines Authority (APVMA) label or permit for use of pesticides, complying with state government control of use legislation and regulations
  - legislated requirements for pesticide and fertiliser application, including requirements for waterways and Great Barrier Reef management
- participating in site risk assessments to determine the suitability of the proposed machinery
- developing the proposal and requirements for the introduction of the machinery
- conducting an initial site risk assessment to determine the suitability of the proposed machinery
- understanding and mitigating the risks associated with the system, including any residual risks
- using the system in accordance with the specifications, instructions and training
- maintaining the integrity over the machinery life cycle by abiding by requirements and specifications
- incorporating information from manufacturers and distributors into the safety management plan
- developing safe work procedures to carry-out the safety management plan
- establishing change management processes for maintaining the safety management plan
- consulting with other owners and operators on implementation practices and potential hazards
- training farm and operator personnel, including:
  - operation, maintenance and servicing
  - calibrating test procedures
  - commissioning information
  - trouble shooting procedures
  - safe work procedures of the safety management plan
- developing and implementing general awareness training for all personnel on site to make them aware of the hazards associated with the machinery and operations
- auditing any site-supplied componentry (e.g. computers, servers, radios, positioning system, Wi-Fi, telecommunications) to confirm its compatibility and security with the requirements of the manufacturer/distributor
- recording, reporting, investigating incidents and taking action to prevent further incidents, in consultation with the manufacturer or distributor
- ensuring ongoing maintenance and service required under the safe work procedures.

2. Safety and risk management process

2.1 Introduction

The operation of mobile machinery with autonomous functions can introduce hazardous situations not normally encountered on a farm site with conventional machinery.

The effective management of the risks associated with mobile machinery with autonomous functions requires input from diverse groups, ranging from researchers, design engineers, manufacturers, importers, distributors, owners, operators, project managers and safety and health representatives.

The risk management process should address the following questions.

- What are the potential scenarios for incidents? (see Appendix 6 for examples)
- What are their potential consequences in terms of safety and health?
- What controls are available and how effective are they?

2.2 Communication and consultation

Communication and consultation are fundamental for ensuring the most effective risk management. In particular, it is essential that the knowledge of the design and manufacture in the form of operating instructions and parameters are considered by the distributor, owner and operator when assessing and minimising associated risks during the operational life cycle.

2.3 Information for risk management

A farming operation safety management plan should be able to demonstrate that the hazards associated with the mobile machinery with autonomous functions are being controlled so far as is reasonably practicable by considering:

- the risk assessment performed by the designer and manufacturer
- the performance specifications and operating parameters of the machine
- the site operating parameters established by the designer and manufacturer
- environmental conditions and restrictions established by the designer and manufacturer
- the results of the on-site (and surrounding area) risk assessment
- suitability of established work procedures (e.g. separation, inspection and maintenance processes)
- whether established emergency procedures are sufficient
- the provision and competency of operational and support personnel (e.g. assessment of knowledge and training needs).

2.4 Risk identification

The use of autonomous technology in an operating farm environment will change established safety management systems. It is important to identify these changes and the associated risks.

Hazard identification systems that can be implemented to ensure risks are identified include:

- a hazard and operability study (HAZOP)
- layers of protection analysis (LOPA)
- functional safety analysis
- employee hazard identification and reporting procedures
- workplace inspections
- monitoring the working environment

- incident investigations
- monitoring OEM and service company bulletins, recommendations and specifications
- safety alerts required under regulation.

Some potential risks for mobile machinery with autonomous functions operating on a farm are listed in Appendix 6.

2.5 Risk analysis

At the risk analysis stage, the nature of the risk is assessed, and the risk level is determined. Factors to consider include:

- probability of occurrence, which includes exposure to the hazard, occurrence of event and possibility to avoid or limit harm
- severity of harm.

It is important that those undertaking a risk assessment have the necessary information, training, knowledge and experience of the:

- operational environment (e.g. scale, complexity and physical environment of farming activities)
- operational processes (e.g. maintenance systems, work practices, interaction, separation)
- semi-autonomous and autonomous functions (e.g. system functionality, safety features).

2.6 Risk evaluation and management

All hazards related to mobile machinery with autonomous functions used in agricultural operations need to be identified and controlled. This is best done by applying the hierarchy of control. Higher-order control measures eliminate or reduce the risk more effectively than administrative controls or personal protective equipment.

For mobile machinery with autonomous functions, it is advisable to consider implementing:

- primary controls that:
  - avoid the risk by deciding not to start or continue with the activity (e.g. cease operations during adverse weather)
  - remove the source of the risk (e.g. isolate or provide alternative access for personnel not directly involved with the autonomous activity)
  - change the likelihood (e.g. restrict specific functions to authorised personnel)
  - change the consequence (e.g. decrease speed, limit area of operation)
- contingency controls that minimise the effects if there is an incident (e.g. layers of protection, systems that fail to the safe state).

Prevention and management controls should be based on established processes and relevant standards, including:

- safe design, construction and installation (according to specifications and design parameters)
- separation from manned operations where possible
- effective change management processes
- operational and maintenance safe work procedures (SWPs)
- competency-based training and assessment of workers
- supervision and management oversight.

2.7 Monitoring and review

To ensure the effectiveness of controls is maintained at the site, a monitoring and review program should be implemented that includes control audits, verification and validation.

As part of the site's validation process, responsibilities and accountabilities should be clearly defined and assigned, and may include independent auditing. The findings should be used to:

- confirm that the recommendations of previous reviews have been actioned
- confirm that appropriate responses have been made to any incidents or issues arising
- verify compliance with specifications (e.g. inspection, monitoring, quality control)
- recommend any necessary operational or system design modifications, which are documented and managed through a formal change management process.

2.8 Documentation

The results of the risk assessment need to be formally documented in the operation's risk register, detailing the:

- locations of mobile machinery with autonomous functions area of operation
- size and complexity of operations
- types of potential incidents
- consequences and likelihood of each incident
- controls used to mitigate each risk to a practicable minimum
- monitoring and review outcomes and actions.

The documentation of this information forms the basis of the farm site's safety management plan for mobile machines with autonomous functions used in agricultural operations.

Used with the permission of CNH

3. Information, instruction, training and supervision

3.1 Introduction

The provision of information, instruction, training, servicing and supervision is an essential component of any farm site's safety management plan.

3.2 Information

Personnel must have the information necessary to complete tasks safely. Such information may include:

- manuals, specifications and standard operating procedure instructions provided by the manufacturer or distributor
- the farm site's operation policies, procedures and plans
- applicable legislation, Australian and International Standards, and other guidance material.

3.3 Instruction

Personnel must be instructed about system functionality and specific tasks to be undertaken, including the hazards and risks, the controls to be applied, and the job steps necessary to complete the tasks safely and correctly.

Instructional tools such as safe operating or safe work procedures (SOPs or SWPs) and standard operating procedures (SOPs) may be used to document the process but should be reviewed and amended if there are any changes (e.g. equipment, conditions).

If there is to be a deviation from the SWPs, a job safety or hazard analyses (JSAs or JHAs) should be undertaken to capture the hazards for the task and ensure controls are implemented.

Such instructional tools must be formally approved by the supervisor or management.

3.4 Training

Personnel must be competent in the tasks they are assigned. This means they must have the knowledge and skills necessary to perform the task safely and correctly. Competency is gained through training and experience while being supervised or mentored.

The risk management training provided must be appropriate to the assigned roles and responsibilities, and provide information on:

- the risk management process
- task-specific safe work methods, including the safe use of equipment and safe systems of work.

All personnel should understand the effects that their activities may have during commissioning, operation and maintenance of the mobile machinery with autonomous functions. They should also understand:

- what to expect if environmental or operational conditions change
- site requirements for monitoring of machine performance
- how to recognise when machines are not operating as intended
- how to report incidents.

Assessment of competency should be evidence-based and verified before work commences.

Competency may be verified by:

- recognition of prior learning
- on-site recognition or validation of current competency
- using the operation's training and development program.

Verifications of competency must include a documented assessment.

Whenever procedures of work and equipment change, or new procedures of work and equipment are introduced, there must be a system to ensure affected personnel are consulted, retrained as necessary and reassessed.

3.5 Supervision

Supervision is a fundamental safety action that complements the provision of information, instruction and training. Effective supervision sets and maintains high standards of performance.

Supervisors within a farming operation help achieve the operation's safety and health goals in a variety of ways, including:

- leading and managing their team using their understanding of the key principles and safety features of the machinery
- ensuring work is carried out in accordance with manufacturer or distributor documentation
- confirming workers (including contractors) are trained and assessed as competent to perform their duties
- communicating regularly with those affected by work
- confirming fit-for-purpose equipment is available and used
- monitoring the workplace, and identifying and controlling hazards in accordance with site rules
- confirming the operation's risk register reflects the risk analysis of jobs and critical tasks
- reporting and recording performance issues (e.g. equipment failures, variances to approved operating parameters)
- referring new and changed circumstances not covered in site rules to management for further instructions
- communicating learnings from incidents.

Used with the permission of John Deere.

4. Introduction to general hazard controls

The operation of mobile machinery with autonomous functions can introduce hazardous situations not normally encountered on a farm site with conventional machinery. These additional hazards require detailed consideration and risk assessment to ensure they are effectively managed.

The hazard controls in place for operating mobile machinery with autonomous functions over time should provide an equivalent or better safety performance than what could reasonably be expected from a non-autonomous operation, even in the event of loss of system communications (e.g. with the primary control system).

To understand and adequately assess inherent or residual risks and implement appropriate controls, matters to be considered should include:

- suitability and design for the operational environment
- identification of any limitations of the autonomous technologies
  - o functionality
  - o multiple autonomous systems operating in close proximity
    - use of mixed, hybrid and after-market technologies
- identification of any limitations of operational processes
- competency of operational and support personnel
- records management
  - o risk register
  - o monitoring and maintenance of controls (e.g. systems security)
  - o system incidents and actions to prevent further incidents
  - o system performance monitoring over the life (e.g. system functionality)
- change management
  - o Communication and consultation
  - o Change control and traceability
- any ‘new’ factors.

Used with the permission of Kubota

5. Farm planning and design for hazard control

5.1 Introduction

The following fundamental principles need to be built into farm design and planning processes early in the project:

- risk management (see Chapter 2)
- designing and planning for mobile machinery with autonomous functions
- managing and minimising interactions
- infrastructure to support mobile machinery with autonomous functions.

5.2 Designing and planning for autonomy

Designs and plans for farms should take into account the limitations of any autonomous farming technology being used, including:

- application of engineering and system controls to safety processes and practices
- modification of established planning and operational processes
- verification of system data (e.g. surveys) to validate farm designs and plans
- knowledge and competency of planning and operational personnel.

5.3 Managing interactions

Designs and plans for farms should ensure work area design and construction are suitable for mobile machinery with autonomous functions and minimise interaction with personnel, taking into account:

- manufacturer or distributor recommendations
- access controls and processes for exclusion of people, animals, machines and vehicles
- traffic management (e.g. internal farm road access network)
- placement of infrastructure within the autonomous operating zone such as
  - input resources e.g. fuel, fertiliser, chemicals
  - workshops and service areas
  - calibration and commissioning areas
  - communication, water, gas and power service areas.

5.4 Autonomous infrastructure

The design, location and integration of infrastructure to enable mobile machinery with autonomous functions should consider:

- the scalability and capability of the system and associated infrastructure
- number of machines, equipment specifications, machine size and operating capabilities (e.g. turning circle, internal farm road access network)
- communication systems (e.g. public or private)
- area access (e.g. location and control of area entry and provision of signage at exit points)
- monitoring system health (e.g. communications, positioning systems).

5.5 Operating environment

Designs and plans for farms should ensure work areas are suitable for mobile machinery with autonomous functions, taking into account:

- work areas and internal farm road access, design and construction are in line with the manufacturer or distributor requirements
- traffic management on farm (e.g., loading and unloading areas, access controls for exclusion and interface areas)
- area segregation (e.g. service areas, calibration and commissioning areas).

5.6 Change management

Designs and plans for farms should ensure a comprehensive change management system is employed for introducing use of mobile machinery with autonomous functions, including:

- operational and maintenance practices
- training, monitoring and reporting
- maintaining data for safety management.

See Appendix 4 for examples of a farm project management plan.

Used with the permission of CNH

6. Machinery design for hazard control and functional safety

Manufacturers and distributors are also required to identify, assess and control the hazards associated with semi-autonomous or autonomous functions of mobile machinery in agricultural operations. Functional safety also provides assurance that the functions and operational controls will provide safe operation in the event of a failure or fault. Mobile machinery with semi-autonomous or autonomous functions should be designed:

- using risk assessment and risk reduction principles (see Appendix 2)
- in accordance with relevant standards (see Appendix 2)
- to meet statutory obligations (e.g. communication network licenses).

To achieve adequate risk reduction and performance levels for safety functions, manufacturers and distributors should consider the following in the design and verification of mobile machinery with semi-autonomous or autonomous functions:

- clearly defined roles and responsibilities of owners/operators, manufacturers and distributors
- system design:
  - layers of protection and redundancies in the systems (e.g. perception and collision avoidance systems, sensitive area mapping and exclusion, pesticide and fertiliser application buffer zone separation)
  - configuration management and security to prevent unauthorised modification of settings, position parameters and base guidance affecting operational performance, environment and safety
  - approval through change management process before design changes are implemented
  - process to conduct post-change review and acceptance testing for design changes
  - if elements of the system fail then the system is designed to fail (shutdown) to a safe condition
  - assessment of human interactions with the machinery (e.g. operational and maintenance personnel in autonomous operating zone)
    - the impact of human interactions and behaviours (e.g. level of intervention actions for alarms and warnings)
  - periodic reviews of the system performance and parameters in accordance with design parameters
  - records kept of changes to the control system, operating practices or parameters.

7. Commissioning hazard controls

To achieve the desired safety outcomes, commissioning activities for mobile machinery with autonomous functions should adequately address matters such as:

- roles and responsibilities of owners/operators, manufacturers and distributors
  - o boundaries agreed, defined and documented
  - o commissioning tasks assigned to competent persons
    - formal commissioning and hand-over process
- Risk management process
  - o technology and specific functionalities are understood
  - o identify hazards specific to the commissioning phase (e.g. safety critical tests)
  - o ensure appropriate controls are in place
- planning
  - o communications and reporting plan
  - o commissioning project plan and timeline
  - o selection and survey of suitable commissioning area (e.g. segregated, isolated)
  - o checklists for installation, assembly and commissioning
  - o change management plan
- testing
  - o based on the recommended commissioning procedures from the manufacturer/distributor
  - o safety systems tests
  - o operational performance tests
  - o system integration tests
  - o documented test procedures
- training and induction
  - o training and induction conducted in line with documented manufacturer information
  - o training and induction should be traceable to the machinery version or type to confirm systems meet the manufacturers and distributors operational requirements
  - o compliance with relevant regulations (e.g. pesticide application)
    - training and induction documented
    - systems acceptance
  - o formal process for managing unresolved defects and issues
  - o owner/operator acceptance based on manufacturer and distributor specifications
    - training and assessment of competency for the various roles.

8. Operational hazard controls

To achieve the desired safety outcomes, the design and function of operational practices should adequately address matters such as:

- management and supervision, including support functions
- technical and system knowledge within operating teams
- roles and accountabilities
  - job descriptions
  - changes introduced by mobile machinery with autonomous functions
- competency validation (e.g. operators, supervisors, technical and service support)
- change management such as
  - system updates and upgrades
  - changes to operational practices, documentation and training requirements
  - sharing safety learnings
- interaction rules
  - how changes between semi-autonomous, autonomous and manned operating modes are managed, documented and communicated
  - traffic management and associated procedures to govern interactions between semi-autonomous, autonomous and manned machinery
- human factors (e.g. response to system information or warnings, adherence to exclusion zones)
- performance monitoring of continuous improvement and change management (e.g. equipment, systems, personnel)
- area security and control
  - access control for semi-autonomous, autonomous, manned and mixed equipment operational areas accounting for the number of machines, equipment specifications, machine size and operating capabilities
  - area or hazard inspections that incorporate checks for area security and control
- tools and processes
  - risk management (SWPs, JSAs, risk assessments, risk register)
  - communication protocols and considerations (e.g. radio network)
  - monitoring
  - incident reporting
  - emergency response
- technical support provision.

Note: Restricted operational modes may be appropriate to consider following certain non-critical system events.

9. Vehicle transport between fields

There is a common producer need to transport agricultural equipment across and along public roads, sometimes over considerable distances. It is recognised it will be very difficult to automate transport between fields and across public land and roads until there is a national policy for automated road transport.

This Code of Practice is for in-field, on-farm operation only. The Code of Practice does not cover the use of autonomous or semi-autonomous equipment for on-road use.

All semi-autonomous and autonomous equipment should be in full view and control of a manual operator at all times on public land and roads as per current state transport conventions and regulations under the National Class 1 Agricultural Vehicle and Combination Mass and Dimension regulations of the National Heavy Vehicle Regulator.[4]

Transport on private land between farm fields would deliver significant operational efficiency benefits if incorporated into semi-autonomous and autonomous agricultural equipment. Regulations may be developed to support this in the future.

10. Maintenance and repair requirements

To achieve the desired safety outcomes, maintenance and repair activities for autonomous equipment must recognise:

- operators will not tamper in any way with the operational integrity and safety of autonomous equipment while it is supported by the manufacturer, noting that older systems may require third party support in time.
- operators should only change sensors in the field, which has the support of the manufacturers, recognising that timeliness of repair is important
- calibration and validation testing following a component repair, upgrade, system change or return to autonomous service must be carried out according to the autonomous equipment manufacturer SOP.

4 https://www.nhvr.gov.au/road-access/national-harmonisation-program/national-class-1-agricultural-vehicle-and-combination-notice

Used with the permission of AGCO

11. Emergency management

The potentially hazardous nature of autonomous equipment in farming operations, and often remote locations where they are carried out, mean that being prepared is critical to the health and safety of personnel. Emergency management involves understanding the likelihood of an emergency situation and its potential consequence, and being prepared to mitigate its effects, respond effectively, and recover afterwards. Effective emergency management means that there are plans in place for all foreseeable emergency scenarios, so the response is comprehensive and coordinated.

Farm staff should be inducted to the site and have an understanding of how the system works and the controls required before entering an autonomous operating zone.

Emergency response planning for autonomous equipment operations should be undertaken as part of the farm emergency response planning to ensure the integration of responses where necessary. It should be noted that safe access and effective communication during an emergency can be difficult to establish and maintain.

The system should include emergency response procedures to:

- isolate all, or part of, the autonomous operating zone
- shut down the mobile equipment.

The critical element of preparedness is the development of emergency response plans for identified emergency scenarios, e.g. such as fire. Risk mitigation plans should consider fire management. All personnel inducted to the site should be familiar with the emergency response strategy before entering the site to ensure they understand their responsibilities and what to do in an emergency.

Emergency response plans and procedures, including operation of safety stop operation should be regularly tested to ensure their effectiveness. Both “desk-top” tests and emergency response drills involving all onsite personnel should be carried out. Planning and systems should be regularly tested as required by regulations.

Debriefings conducted as soon as practicable after an emergency or drill will help identify potential improvements to the emergency response plan.

Used with the permission of Croplands and Raven

Appendix 1. Legislative provisions

All work health and safety and environmental incidents should be reported as required by current state laws. The Australian grains industry Grains Guide[5] includes the following guidelines to meet work health and safety obligations:

- Employers must as far as reasonably practicably provide a safe workplace and system of work so that employees (workers), advisers and contractors are not harmed or injured at work.
- Within your chain of responsibility:
  - take all reasonably practicable safety measures to eliminate or minimise potential harm or loss
  - comply with regulatory requirements for dangerous goods and hazardous chemicals transport and storage.
- Ensure machinery and equipment is appropriate for its use and is maintained.
- Continually work through these steps for managing farm safety as defined in legislation:
  - CONSULT - Ensure staff, advisors and contractors are involved in (consulted about) WHS hazards. Record WHS meetings.
  - IDENTIFY HAZARDS - Develop a Work Health and Safety Plan to regularly identify WHS hazards.
  - ASSESS and CONTROL RISKS - Identify machinery and tasks that are a risk for workers; take action to eliminate these risks or develop procedures to control or manage risks that cannot be eliminated.
  - REVIEW - Review and revise risk control measures regularly and when potential new risks arise.
  - ADMINISTRATIVE CONTROLS - Make sure workers are equipped to work safely:
    - Safety induction of all staff and contractors that includes understanding of known hazards/ risks (e.g. a checklist), worksite preferred controls for these, emergency procedures and contact details.

5 https://grainsguide.grainproducers.com.au/safety

- Training and instruction - train workers how to use machinery safely and make sure that safe work procedures are followed. Ensure that all persons are properly trained for the work they are assigned.
- Records - maintain a register of staff training and induction.
- Personal protective equipment - provide safety equipment and clothing where necessary for the specific situation and/or specific workers. e.g. dust protection may be needed for asthmatics.
- Providing amenities for workers - e.g. toilets, meal rooms.
- Safety facilities - provide First Aid training and kits, fire extinguishers and emergency plans.
- Reporting safety - establish a system for workers to report hazards, injuries and serious near-miss incidents. Act upon these reports.

The parts of the Safe Work Australia Model Work Health and Safety (WHS) guidelines[6] related to identify, assess and control WHS hazards[7] and manage risks that are directly applicable to this COP are listed below.

Management commitment

Effective risk management starts with a commitment to health and safety from those who operate and manage the business or undertaking. You also need the involvement and cooperation of your workers, supply chain partners, and other businesses you work with. Management commitment is about demonstrating you are serious about health and safety and influencing other duty holders in the workplace.

To demonstrate your commitment, you should:

- get involved in health and safety issues so that you understand the hazards and risk associated with your operations
- consult workers and other duty holders on the hazards and risk, and how to control them
- invest time and money in health and safety

6 https://www.safeworkaustralia.gov.au/law-and-regulation
7 https://www.safeworkaustralia.gov.au/risk

- ensure you and your workers clearly understand health and safety responsibilities and have the knowledge and skill to do tasks safely
- apply health and safety values and behaviours to your own work practices.

A step-by-step process

A safe and healthy workplace does not happen by chance or guesswork. You have to think about what could go wrong at your workplace and what the consequences could be. Then you must do whatever you can (in other words, whatever is 'reasonably practicable') to eliminate or minimise health and safety risks arising from your business or undertaking.

This process is known as risk management and involves the four steps set out in the Safe Work Australia *How to manage work health and safety risks - Code of Practice:*[8]

- Identify hazards - find out what could cause harm.
- Assess risks, if necessary - understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening. This step may not be necessary if you are dealing with a known risk with known controls.
- Control risks – implement the most effective control measure that is reasonably practicable in the circumstances and ensure it remains effective over time.
- Review hazards and control measures to ensure they are working as planned.

This process will be implemented in different ways depending on the size and nature of your business or undertaking. Larger businesses and those in sectors where workers are exposed to more or higher risks are likely to need more complex, sophisticated risk management processes.

Determining what is 'reasonably practicable'

Deciding what is 'reasonably practicable' to protect people from harm requires taking into account and weighing up all relevant matters, including:

- the likelihood of the hazard or risk concerned occurring
- the degree of harm that might result from the hazard or risk
- knowledge about the hazard or risk, and ways of eliminating or minimising the risk
- the availability and suitability of ways to eliminate or minimise the risk, and
- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

8 https://www.safeworkaustralia.gov.au/system/files/documents/1901/code_of_practice_-_how_to_manage_work_health_and_safety_risks_1.pdf

Pesticide application with semi-autonomous or autonomous agricultural equipment

If using agricultural pesticides with semi-autonomous or autonomous mobile agricultural equipment, then the application of pesticides must comply under legislation[9] with the registered Agricultural Pesticides and Veterinary Medicines Authority (APVMA) label or permit for use of pesticides[10] and comply with state government control of use legislation and regulations.[11]

Use of autonomous equipment would result in improved legislative compliance and record keeping for pesticide application due to the precision and systems involved.

Application using semi-autonomous or autonomous equipment would be applied to label or permit requirements only in the correct environmental conditions.

Potential use of semi-autonomous or autonomous equipment for pesticide application for label or permit compliance will be defined by the standard operating procedure supplied for the particular piece of equipment.

Application of pesticides and the potential mixing of pesticides using semi-autonomous or autonomous equipment is the key decision point of responsibility for meeting legislative obligations and the person doing this and actioning the equipment would be legally responsible for the pesticide application action.

Use of semi-autonomous or autonomous equipment does not remove the responsibility of the operator from meeting legislated requirements for pesticide application. Semi-autonomous or autonomous pesticide application as per legislated label and permit requirements will include monitored operator based decisions based on local validation for application in suitable weather conditions with best practicable available data provided in real-time with the required buffer zones and associated record keeping of site-specific pesticide application.

Future autonomy for pesticide application equipment decision-making may include AI systems in the future to comply with legislated pesticide label and permit requirements as sensor systems and standards evolve.

Semi-autonomous and autonomous equipment will comply with legislated requirements for pesticide and fertiliser application, including requirements for waterways and Great Barrier Reef management.

Note: The only authorised versions of the Act and regulations are those available from the relevant State Law Publisher, as the official publisher of legislation and statutory information.

9 https://apvma.gov.au/node/4131
10 https://portal.apvma.gov.au/pubcris
11 https://apvma.gov.au/node/15891

Appendix 2. Selected standards

Examples of Australian and International Standards (ISO) and other guidance that may apply to mobile machinery autonomous functions used in agricultural operations are listed below.

Note: This list is not exhaustive but gives an indication of the many aspects to be considered.

Risk Assessments and Risk Reduction

- AS/NZS ISO 31000 Risk Management – Principles and guideline
- ISO12100 Safety of machinery - General principles for design - Risk assessment and risk reduction

Design

- AS/NZS 3100 Approval and test specification - General requirements for electrical equipment
- AS/IEC 61508.1 Functional safety of electrical/ electronic/programmable electronic safety-related systems - General requirements
- AS/NZS 60529 Degrees of protection provided by enclosures (IP Code)
- ISO13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design https://www.iso.org/standard/69883.html
- ISO 13849-2 Safety of machinery - Safety-related parts of control systems - Part 2: Validation https://www.iso.org/standard/53640.htm
- ISO 25119-1 Tractors and machinery for agriculture and forestry - Safety-related parts of control systems - Part 1: General principles for design and development https://www.iso.org/standard/69025.html
- ISO 25119-2 Tractors and machinery for agriculture and forestry - Safety-related parts of control systems - Part 2: Concept Phase
- ISO 25119-3 Tractors and machinery for agriculture and forestry - Safety-related parts of control systems - Part 3: Series development, hardware and software
- ISO 25119-4 Tractors and machinery for agriculture and forestry - Safety-related parts of control systems - Part 4: Production, operation, modification and supporting processes
- ISO 14982 Agricultural and forestry machines - Electromagnetic compatibility - Test methods and acceptance criteria
- ISO 10975 Tractors and machinery for agriculture - Auto-guidance systems for operator-controlled tractors and self-propelled machines - Safety requirements https://www.iso.org/standard/46481.html
- ISO 18497 Agricultural machinery and tractors - Safety of highly automated agricultural machines - Principles for design https://www.iso.org/standard/62659.html

  Note ISO 18497 is currently being revised by CEMA – European Agricultural Machinery Association Project Team 4 – Safety of Autonomous Functions into a multi-part standard with vocabulary, principles for design related to general safety and obstacle protective systems. Refer to latest drafts and work item status in the appropriate working group of ISO Technical Committee TC23 / Sub-Committee SC19 until officially published.
- ISO 4254 Series: Agricultural machinery - Safety
- ISO 26322 Series: Tractors for agriculture and forestry - Safety

Appendix 3. Glossary

In order to reduce confusion and ambiguity, it is recommended that standard terminology is applied. For the purposes of this document, the following terms are defined.

Automatic - a process or part of a process when machine functions follow defined rules.

Autonomous - automated machine functions that operate in autonomous mode during all of the machines operating cycle.

Autonomous operating zone - designated area in which machines operate in autonomous mode.

Collision - unintended contact between two or more objects.

Manufacturers and distributors - those who design, manufacture, import, sell, supply and commission mobile machinery with semi-autonomous or autonomous functions.

Mechanised - commonly used when a certain process is done with the aid of machines.

Owners or operators - those who use the machinery, including operators, contractors and maintainers.

Remote controlled - the functionality and operator interface are the same or similar on the machine, but the controller is separate to the machine and is under human supervision while the machine is operated in line-of-sight or tele-remote mode.

Safe state - operating state of a system with acceptable level of risk for operator or bystander even when the control system fails or partly fails.

Semi-autonomous - automated machine functions that are intended to operate in autonomous mode during part of the machines operating cycle in addition to non-automated and automated machine functions that are intended to operate in manual mode to complete some of the tasks assigned.

Appendix 4. Farm project management planning and implementation

Requirements

A farm business proposing implementation of autonomous field equipment (including mobile machinery with autonomous functions) must establish a farm project management plan (PMP).

The introduction of autonomous field equipment to a farming operation, new or existing, can add hazards beyond those associated with a conventional manned farming operation. These additional hazards will require detailed consideration and risk assessment to ensure they are effectively managed.

Submission of the PMP for autonomous field equipment used in farming should be seen not only as a legislative requirement, but an opportunity to demonstrate an understanding of the risks associated with implementing autonomous technology. The PMP is an important tool in the development of a site-specific occupational health and safety management system.

Content

The following headings cover the PMP content for autonomous field equipment used in farming projects. The plan should set out clear objectives, stating what will be done, how it will be done, and the proposed schedule for doing it.

Section 1: Introduction

1.1	Proposed autonomy implementation project
1.2	Make-up of system
1.3	Communications and reporting processes
1.4	Implementation process
1.5	Risk management strategy
1.6	Limitations of system

Section 2: Project overview

2.1	Location
2.2	Access
2.3	Equipment
2.4	Plan and timeline
2.5	Organisation
2.6	Key roles
2.7	Skills and knowledge of implementation team

Section 3: Functionality of the system

3.1	Mobile machinery with autonomous functions
3.2	Manual vehicles
3.3	Autonomous and non-autonomous operating zones
3.4	Autonomous mode/manual interface (operation/maintenance)
3.5	Navigation systems
3.6	Safety systems and control systems flowcharts
3.7	Other functionalities
3.8	System redundancy
3.9	Safety integrity level/failing to safe
3.10	Compliance with relevant Australian/International Standards
3.11	Interactions and tasks within the autonomous operating zone

Section 4: Equipment control system

4.1	Layers of protection
4.2	Communication
4.3	Controller integration
4.4	Controller recording

Section 5: Farm and operations

5.1	Key principles
5.2	Facilities with the autonomous operating zone
5.3	Farm design principles
5.4	Machine operational area movement
5.5	Supervision
5.6	Contract management
5.7	Other requirements (eg soil type/typography, sensitive areas)

Section 6: Commissioning, maintenance and inspections

6.1	Commissioning process
6.2	Maintenance and inspection strategy
6.3	Maintenance and inspection of ancillary equipment
6.4	Maintenance and inspection of light vehicles
6.5	Maintenance and inspection of control system

Section 7: General safety plan

7.1	Safety management plan
7.2	Risk management applied to the project
7.3	Other major risks eg fire (normal PMP hazards/controls)
7.4	Mobile machinery with autonomous functions risk management strategy
7.5	Change management strategy
7.6	Process monitoring
7.7	Review and auditing

Section 8: Training and competence assessment

8.1	Training program
8.2	Ramp-up plan

Section 9: Means of investigating failures

9.1	Failure reporting
9.2	Failure investigation

Section 10: Resulting documentation to be held on farm

Appendix A	Plans
Appendix B	Detailed risk assessment
Appendix C	Emergency response plan
Appendix D	Inspection protocols
Appendix E	Protocol testing

Appendix 5. Introducing mobile machinery with autonomous functions to farming operations

Applications

Autonomous functions can be used in many different mobile machinery farming operations. Examples include:

- scouting vehicles
- tractors
- sprayers
- haymaking equipment
- harvesting equipment

Decision to utilise autonomous technology

The decision to utilise autonomous technology in parts or all of a farming operation is a commercial decision based on perceived future gains in productivity, efficiency and safety performance.

Many large farming companies and machinery manufacturers have been involved with pilot projects in Australia for a number of years and are introducing semi-autonomous and autonomous functions of mobile machinery such as, but not excluding, scouting vehicles, tractors, sprayers and haymaking and harvesting equipment into production activities.

While the decision to utilise autonomous technology for particular aspects of farming activities depends on the project's financial and logistical viability, farm businesses should demonstrate through a project management plan, that they can effectively accommodate this new farming approach in their safety management system and manage the change.

The addition of autonomous functions in mobile machinery can introduce hazardous situations not normally encountered on a conventional manned farming operation.

It is important that these safety challenges are addressed early in the planning cycle to maximise opportunities for solutions high in the hierarchy of control (i.e. elimination, substitution, engineering).

Companies considering introducing mobile machinery with autonomous functions into their operations should consider the following to achieve a safe and successful outcome:

- undertake a comprehensive farm site risk assessment prior to making the decision to introduce the technology into farming operations
- have a well-documented change management process, including
  - roles and responsibilities
  - development of strategies
- integrate mobile machinery with autonomous functions into farm design and planning as early as possible.

Assessing suitability of operation for autonomous functions

Scoping the case

The introduction of autonomous field equipment in farming is not a trivial matter as its impact will be felt in many areas of a farming operation. Although the technology provides opportunities, it may not be suitable for some sites. The benefits of autonomous field equipment are most obvious for use in crop scouting, tractor tillage, spraying, fertilising and haymaking operations where simple monitoring is required and repeat operations is a practical consideration. More complex tasks such as planting, and harvesting requires more complex monitoring and is time critical.

There needs to be a well-defined business case that addresses potential issues that may negatively impact desired outcomes.

The business case should address questions such as:

- What are the expected safety and organisational benefits?
- What are the hazards and limitations of the introduced technology?
- If there is an existing operation, what hazards may emerge that need to be considered and managed during integration?
- What is a realistic lead time for full implementation, given the need for verification and validation trials as part of the risk management process?

Farm businesses should invest sufficient time and resources to ensure mobile machinery with autonomous functions can start up safely and meet production expectations. Matters to be considered include:

- organisational readiness
- project management
- site-specific risks.

For a technology implementation project to be successful, attention is required in three key areas - people, processes and technology.

People

The workforce will be affected by the introduction of autonomous technology, particularly in regard to training and skills d1evelopment. Furthermore, roles and skill requirements will change - new skills will be part of new organisational structures and some existing skills may no longer be applicable.

Potential changes need to be identified and managed carefully for the implementation of autonomous technology to be successful.

Processes

Autonomous field equipment will change the way in which the farm operates. It will impact many procedural aspects of farming such as:

- farm traffic management plans
- safety management plans
- safe work procedures
- work instructions.

These will need to be identified and developed in a timely manner to ensure the introduction of mobile machinery with autonomous functions has the best chance of success.

The farm layout, farm design, farm plans and schedules will need to be tailored to accommodate mobile machinery with autonomous functions and modifications need to be identified as early as possible to allow for sufficient time to incorporate any changes.

Technology

The implementation of autonomous technology potentially requires the application of other technology such as sophisticated and robust wireless communications networks and control rooms. These will need to be identified and be part of the deployment process.

Organisational readiness

The ease with which autonomous field equipment can be introduced to a site will depend on the organisation's level of preparedness, at all levels, for the new technology. The greater the complexity of the proposed changes, the greater the importance of understanding whether there is a readiness for change and identifying the actions required to achieve the desired safety and performance outcomes.

Factors influencing organisational readiness include:

- robustness of safety culture
- commitment to effective change management
- responsiveness to change
- existing knowledge and understanding of mobile machinery with autonomous functions in farming, its risks and consequences
- human resourcing
    - identification of new roles, responsibilities and reporting relationships
    - recruiting to address skill gaps and capacity of workforce to transition between mechanised and using mobile machinery with autonomous functions in farming
    - ability to learn
    - adaptability of process and operation personnel
    - awareness of the level of discipline required for mobile machinery with autonomous functions in farming.

The successful introduction of mobile machinery with autonomous functions in farming requires:

- commitment from the board and senior management to ensure sufficient time and resources are allocated
- a clear vision of the project and outcomes
- defined responsibilities and accountabilities
- a collaborative approach so knowledge is shared, not only within the organisation but with machinery manufacturers, importers and distributors
- workforce acceptance of the implementation strategy.

Change management

A well-constructed change management policy is critical to the introduction of autonomous field equipment. Successful change management will require the input and alignment of all parties involved in the process, including:

- principal employer
- project team
- farm management
- manufacturers, importers and distributors
- workforce, including contractors
- safety and health representatives
- safety regulator.

The change management strategy may need to be different for each part of the site and type of autonomous field equipment introduced. Key aspects to be managed should include:

- procurement and installation
  - selection of mobile machinery with autonomous functions, including equipment specifications and associated technologies
  - commissioning of the mobile machinery with autonomous functions (both the "conventional" equipment as well as the on- and off- board control systems)
- hand-over, including testing and monitoring requirements.
- farm planning
  - farm design - mobile machinery with autonomous functions will have specific operating requirements (e.g. farm dimensions, layout of road network)
  - farm plans and schedules - although mobile machinery with autonomous functions are designed to be intrinsically safe, further reduction of risk is best accomplished by minimising interactions with autonomous field equipment at the farm planning and scheduling phases.
- operational procedures
  - traffic management
  - access to and egress from an autonomous operating zone
  - workplace inspections in an autonomous operating zone
  - working near mobile machinery with autonomous functions
  - mobile machinery with autonomous functions inspection, servicing and maintenance
  - verification and validation to assess system integrity.
- personnel
  - organisational structure and control of safety - new roles and organisational structures may need to be considered
  - training and competency assessment in advance of system implementation is challenging prior to system implementation - machinery suppliers and service providers may have specialist skills and facilities that can be used
  - a system to ensure affected personnel are retrained and reassessed as changes occur.
- communication
  - implementation strategy
  - integration of mobile machinery with autonomous functions into the operation
  - potential impact of changes on procurement, farm planning, operational procedures and personnel.

Integration of mobile machinery with autonomous functions into farm planning process

The introduction of autonomous field equipment is typically a staged process that takes time to design and implement. Autonomous field equipment should not be simply seen as a "plug and play" system due to the complexity of the system and layers of safety that need to be built in.

Companies need to carefully evaluate why they wish to utilise mobile machinery with autonomous functions on a site. Owners and operators should evaluate their farm design and undertake a comprehensive risk assessment of the farming processes with support from site representatives and subject matter experts to satisfy the regulator that there are sufficient and robust controls.

Controls should seek to:

- minimise the start-up risks with new plant (e.g. start simple and small and gradually build up capacity)
- create an area where the autonomous field equipment is isolated or interactions with conventional, manned farming systems are managed (e.g. consider the implications in farm design, plans and schedules)

Supporting infrastructure and area requirements need to be identified early in the project, as mobile machinery with autonomous functions may have specific needs (e.g. fuelling facilities, control centres, communications network).

The following fundamental principles need to be built into farm design and planning processes:

- risk management
- designing and planning for mobile machinery with autonomous functions
- managing and minimising interactions
- mobile machinery with autonomous functions infrastructure.

Risk management

Issues that subject matter experts should consider when undertaking a risk assessment for mobile machinery with autonomous functions in farming include:

- any previous events or information (e.g. incident and injury reports, data from similar technology applications)
- reliability, maturity and available safety features of similar machinery and systems
- provision and frequency of validation process (e.g. trials)
- suitability of established work procedures (e.g. inspection and maintenance processes)
- whether established emergency procedures are sufficient
- the provision and competency of operational and support personnel
- identification of specific risks and provision for regular reviews of controls.

Designing and planning for mobile machinery with autonomous functions

Farm designers and planners should understand both the benefits and limitations of any technology being considered, including the:

- application of engineering and system controls to safety processes and practices
- modification of established planning and operational processes
- verification of system data (e.g. surveys) to validate farm designs and plans
- adaptability of planning and operational personnel
- application of positive outcomes to operations without mobile machinery with autonomous functions.

Managing and minimising interactions

Farm designers and planners should ensure work area design and construction are suitable for mobile machinery with autonomous functions and minimise interaction with personnel and equipment, taking into account:

- access controls and processes for exclusion and interaction areas, such as
- resupply of consumables (e.g. fuel, pesticides and water)
- traffic management (e.g. farm road network, intersections)
- transitions between semi-autonomous or autonomous and other operating modes (e.g. procedures for checking, clearing and acknowledging the transition)
- placement of infrastructure within the autonomous operating zone such as
  - fuel facilities
  - input supplies, workshops and service areas.

Mobile machinery with autonomous functions infrastructure

The design, location and integration of autonomous field equipment infrastructure should consider:

- machinery specifications, fleet size and system capabilities (e.g. turning circle, road network layout, gradient)
- communication systems (e.g. wireless, fixed), and matters such as
  - latency
  - bandwidth
  - spectrum allocation
  - packet loss
  - maintaining connectivity (e.g. wireless cell switch time)
  - redundancy
  - network monitoring
  - autonomous field equipment signage and delineation.

Appendix 6. Potential autonomous field equipment risks

Site-specific risks

If there are no existing operations, then planning for autonomous field equipment can be tailored from the start to address risks common to operations of mobile machinery with semi-autonomous or autonomous functions.

Risk factors to consider as part of a comprehensive risk management strategy include:

- capture of changes to work areas, especially before switching work areas between manual mode and autonomous mode
- loss or interference with communication systems for mobile machinery with semi-autonomous or autonomous functions
- loss of control of movement of mobile machinery with semi-autonomous or autonomous functions, for example sliding or skidding or autonomous field equipment deviating from its programmed path leading to a fall to another level
- other human errors
- inadvertent access
- natural phenomena.

Introduction into an existing operation

Where there is an existing operation, a phased approach may be necessary to manage additional risks associated with integration and segregation, such as:

- infrastructure
- communication
- traffic management.

The following scenarios should be considered for inherent risks, as well as those hazards identified for manned operations:

- access into autonomous operating zone by unauthorised personnel or equipment
- human errors that may lead to mobile machinery with semi-autonomous or autonomous functions going into unauthorised areas or performing tasks that cause safety risks (e.g. human intervention, overriding an alarm condition, failure to update information such as survey plans) design speed of machinery failing to consider operating tolerances
- communications failure leading to lost, degraded, delayed, misdirected or hacked communications, on-board sensor or controller failures
- loss of control movement of mobile machinery with semi-autonomous or autonomous functions equipment (e.g. sliding, skidding)
- mobile machinery with semi-autonomous or autonomous functions deviating from its programmed area
  - o into the path of another vehicle (manned or autonomous)
  - o leading to a fall to another level
- mobile machinery with semi-autonomous or autonomous functions interactions in an environment and traffic management interactions (e.g. failure to convert virtual intersection to actual on the ground)
- failure to communicate changes (e.g. system updates, upgrades, changes to operational practices)

- manual interactions between mobile machinery with semi-autonomous or autonomous functions and traffic management interactions (including escorting of non-system equipment or non-system trained personnel)
- inadvertent switching between autonomous mode and other operating modes leading to loss of control
- interactions with farm visitors and general public
- interactions with walls, windrows or other infrastructure
- passengers, observers and technicians aboard an operating autonomous vehicle
- remote re-starting of mobile machinery with semi-autonomous or autonomous functions from a position without appropriate situational awareness
- fire
- accessing or checking mobile machinery with semi-autonomous or autonomous functions that has failed
- loss of competent persons on site (i.e. staff turnover), leading to loss of corporate knowledge.

Appendix 7. Incident reporting

Mobile machinery with semi-autonomous or autonomous functions in farming should be as safe as or safer than conventional manned farming operations.

Australia has a robust regulatory reporting framework for worksite and environment incidents. An incident in a farming environment with a mobile machine with semi-autonomous or autonomous functions that could happen in a manned or unmanned operation has the same reporting requirements. For example:

- producer businesses have a responsibility to address incidents under risk management requirements in WH&S legislation
- producer businesses have responsibility for reporting to regulators on WH&S, environment and consumer product incidents
- equipment incidents should be reported to your dealer or distributor who, following TMA member protocols, will report the incident to manufacturers for a response
- Incidents involving pesticide application should be reported to the registrant or permit holder to respond according to regulatory requirements, including the state control of use authority and APVMA.