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A supply chain approach to supporting sustainable beef production (Volume 1)

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Abstract

This project involved a detailed review of animal data collection and management practices within a large Australian beef operation. Current practices involved manual aggregation, checking, analysis and generation of reports from animal data. Opportunities for improvements in processes for collecting and managing data were identified and tested. A web-based database system offers a number of advantages covering technical performance and user engagement and compliance. This report provides a number of suggestions for managing data collection and processing from extensive beef enterprises.

Executive Summary

This project, P.PSH.0677 evolved from discussions with McDonalds and beef industry representatives on initiatives that may contribute to industry sustainability through supply chain efficiency and product integrity. Discussions with Paraway Pastoral Company (Paraway) representatives led to a refinement in the focus of this project. The project aim was to review Paraway processes for collecting, managing, analysing and reporting on animal performance measurements, and to make recommendations concerning these practices. The benefits of improvements in data management, analysis and reporting range from better performance monitoring at the enterprise level to better animal-based decisions at the operational level.

The project objectives were to:

- Identify data required to be collected to address Paraway corporate reporting requirements.
- Identify data required to inform operational decision making by both Paraway Property Managers and the General Manager.
- Analyse the suitability of current Paraway data collection (types and process for data collection) to meet both corporate and operational decision making requirements.
- Provide recommendations on data to be collected, timing of data collection, data collection hardware and analysis software to provide the best data collection and analysis system to inform timely decision making by Paraway management.

Paraway management were particularly interested in developing performance measures based on CashCow[1] indices.

Paraway collects crushside data using Gallagher TSi devices and manages data in Gallagher Animal Performance Software (APS) installed on desktop computers in each property office. Detailed protocols have been developed for data management and backup on the properties. Managers send 'whole-of-life' data for each animal to head office twice annually.

Head office staff receive property data files and manage them in Microsoft Excel and (on occasions) Microsoft Access. Processes rely on manual and time-consuming manipulation of incoming datasets. Current systems are more suited to intermittent generation of aggregated performance reports at the property level and annual management reports. The time lag between data collecton on-property and issuing reports from head office means that opportunities for timely feedback to property managers and staff are limited.

The current system involving heavy use of Excel is not sustainable in the longer term as the number of records increases, and has a number of constraints and shortcomings associated with manually controlled operations.

APS did not have a web-based system at the time this work was done. Files are moved by import/export and synchronisation processes between locations. Gallagher Animal Performance Software (APS) offers a feature rich software environment but has a reasonably

[1] Meat & Livestock project B.NBP.0382 *Northern Australian beef fertility project: CashCow*

rigid structure, is not very flexible or easy to customise and provides data export files that require extensive modification in order to analyse in other programs. This has contributed to the challenges for Paraway staff in aggregating, managing, analysing and reporting on data drawn from multiple properties when each manage separate installations of APS.

Paraway's future data management needs will be best met with a custom, web-based database developed using the latest database capability. Current crushside data capture systems can continue with data exported into the database. Algorithms can be implemented to check, clean and aggregate data records, and flag problem records for review and correction. Analyses and reports can be automated and data exported as required for additional ad hoc analyses.

AusVet used a customised, proprietary database system to develop and test methods for web-based data handling and reporting using Paraway datasets, confirming that a combination of automated algorithms and controlled processes can produce the same cleaned datasets and reports as are currently being produced using manual approaches in Excel. The AusVet system was never intended as a long term solution but has served a useful purpose as a development and testing tool.

Key animal traits currently recorded are liveweight, body condition score, pregnancy status, foetal age (recorded as predicted month of calving), and lactation status. A wide variety of additional measures or traits may be recorded depending on needs. Animal identification is a critical issue and a combination of electronic NLIS tag and visual tag as a backup is suggested.

It is critically important that measures be collected on all animals at all occasions, i.e. that compliance with protocols is very high.

Many of the production and reproduction indices of interest to Paraway require recording of repeated data (either within the same year, or across multiple years, or both) for the same animal. Increasing compliance so that repeated measures can be reliably obtained on the same animals, was identified as one of the most important and practical areas where improvements can be made.

APS currently provides a record of those animals that were processed and where EID and animal traits were recorded. APS records do not necessarily provide an accurate count of all animals that may be expected to be in a paddock or on a property at a point in time. This is because not all animals in a paddock were recorded in APS. Some summary performance measures require denominator data (number of cows retained, number of weaners produced and so on). These measures are not able to be automatically generated from aggregated APS records and must be sourced separately from livestock schedule records. As compliance improves, APS records may move to a more accurate representation of all animals. It is suggested that any future database should allow for management of livestock inventory and movement records as well as animal performance records from crushside activities.

The most accurate lactation status information requires two separate recordings per year (two mustering occasions). Recording wet/ dry on a single occasion has an increased risk of error by missing some calving events that occur after the measure.

Reproductive measures are reasonably well defined, and Cash Cow performance measures can be produced using automated routines built into the database.

Care should be taken to standardise protocols for defining and recording animal measures, including how values will be recorded, managed, checked, analysed and reported. Complicated and combined value fields may allow simpler recording of multiple pieces of information at crushside, but may present challenges during aggregation and analysis of stored data.

Liveweight measures are particularly problematic and will require additional care in protocol development. It is suggested that rules be used for checking, identifying and removing suspect or erroneous values, and that weight change over time be limited to measures that are at least 60 days apart. Weigh times should be selected to span growth periods of interest and provide information of value to management at times that are useful to inform management decisions. Weight measures may allow comparisons of average performance from year to year, and between different cohorts of animals, as well as assessing individual performance against cohort and historic means.

A future solution for Paraway will be most effective if it has the following attributes:

- Protocols should be simple, consistent and embedded into routine practices.
- Crushside data collection should be based on a mixture of automated data recording using pre-set defaults or automated recording (date, time, property, paddock, EID, weight, etc) and manual data entry for selected measures (pregnancy status, wet-dry, BCS etc);
- Data should be uploaded into a web-based repository as soon as possible:
    - at crushside if web linkage is feasible
    - at the end of a processing day/ period.
- Automated data cleaning and preliminary checking should be done on data upload, and feedback given immediately to property staff about missing/ incomplete data and possible data errors. Rapid feedback will ensure that property staff have an opportunity to correct errors and add data to maintain complete records.
- Where possible routine reports should be automated so that uploaded data can be analysed and reports are available immediately. This will also help to ensure that property staff can get immediate access to reports and begin to realise value from complete data uploads and effective reporting.
- An important part of property-level performance measures should be based on data collection and completeness to encourage compliance with policies.

Limitations in remote area internet connectivity mean that direct upload from crushside to a central database is unlikely to be achieved in the short- to mid-term. Uploading at the homestead/ office is viable but may still require technical approaches to deal with limited bandwidth.

This project was not designed to deliver a software solution. Customising a web-based software solution to provide the functionality described in this report represents a large, complex and expensive undertaking. This work was explicitly intended to deliver suggestions that could inform future plans to develop, implement and manage a system.

The beneficiaries of this work are expected to be beef producers and agricultural innovators involved in developing and applying software products in beef operations to better manage data flows and reporting.

We recommend that consideration be given to the development of web-based, modular database systems that provide scaleable, flexible and secure repositories for animal data, and that incorporate data checking, analytical and reporting routines.

This report provides various suggestions for characteristics and attributes for such systems.

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Volume 1

1 Background

This project arose from stakeholder interest in projects contributing to industry sustainability through activities associated with collecting and using data across the supply chain to inform decisions.

Initial discussions with Paraway Pastoral (PP) representatives indicated that Paraway Pastoral have invested in weigh systems and associated electronic identification (EID) capture systems to collect animal data in order to measure animal performance and contribute to management decisions.

As part of the McDonald's sustainable beef program and traceability priority, PP are keen to initiate a project that will have the following outputs:

- An analysis of the value of existing data sets and the full information that it can provide, including identification of issues and trends that emerge throughout the year
- A review of existing PP company practice and strategies, including how the TSi system is used in the paddock for data capture and how data is currently analysed and used
- An analysis of the critical points of data that needs to be captured throughout the year to improve the efficiency and effectiveness of the collection and use of the data.
- Development of best practice principles for data capture, analysis and decision making using TSi/EID management systems
- Benefit cost analysis to determine the economic benefits of implementing a targeted monitoring system based on sophisticated data capture and analysis.

There was interest in a project outcome that might include implementation of an efficient data capture system that supports effective management decisions to ultimately improve profit and productivity.

There was also an intention that the key benefits of implementing sophisticated monitoring and measuring systems will be communicated to the broader industry, with PP as the case study.

These initial discussions led to further discussion and modification of project tasks and objectives. The final objectives and related details are presented in the following section.

2 Project objectives

- Identify the data required to be collected to address Paraway corporate reporting requirements.
- Identify data required to inform operational decision making by both Paraway Property Managers and the General Manager
- Analyse the suitability of current Paraway data collection (types and process for data collection) to meet both corporate and operational decision making requirements.
- Provide recommendations on data to be collected, timing of data collection, data collection hardware and analysis software, to provide the best data collection and analysis system to inform timely decision making by Paraway management.

3 Methodology

The project team attended meetings with Paraway Pastoral Company staff at MLA offices in Brisbane, Macquarie offices in Sydney, and Paraway Pastoral Company offices in Orange. Additional communication has been conducted via phone and email.

An attempt was made to broadly map current practices – describe what animal measures are collected, and how data measures are managed, processed, analysed and reported.

This process included understanding animal flows within the Paraway Pastoral beef operations and performance measures of interest along the supply chain.

Example animal datasets and reports were obtained from Paraway Pastoral to allow the project team to review current practices and assess data quality and completeness.

Interim reports described options for how existing systems may be modified to improve collection and usefulness of data, and provided options for possible characteristics of fully featured systems for managing animal performance data.

4 Summary of key findings

4.1 Current practices

Paraway operate multiple beef properties between the NT and QLD.

Northern breeding properties tend to have bulls in the breeding herd all year round, joined heifers are pregnancy tested by 30 April and retained if pregnant, and older cows are managed for exit from about 8 years of age (the aim is to not have any cow older than 10 years) to try and get maximal value from older cows. In some years older females may be spayed prior to selling to maximise liveweight gain prior to sale.

Cull (sale) animals from the breeding operations (cows/ bulls) mostly go to processing in Townsville and Dinmore, but may also go to live export if market access conditions allow, and prices are worthwhile.

Weaners coming from breeding properties will be expected to be about 180-250 kg LWT from first round and 100-150 kg LWT from second round.

Animal flows are presented in diagrammatic form in Figure 2 (see below).

Davenport, Malvern Hills and Athol (agistment block adjacent to Malvern Hills), and Clonagh, are used for pasture-based backgrounding and finishing.

Animal flows are dependent on factors such as animal availability (productivity), animal genotype and phenotype, seasonal conditions and available pasture, prices in different markets, market access/ specifications, and costs.

Crushside data on animal identification and performance (body weight, condition score, pregnancy status, lactation status, etc) are collected through Gallagher systems, including the Gallagher TSi.

Data from all stations is aggregated for subsequent manipulation, analysis and reporting.

At the corporate level, there is interest in ensuring optimal use of data for animal management and profitability.

Performance assessment is mainly based on kg/AE and cost of production per AE.

There is interest in exploring production performance measures such as those developed through recent MLA reports (CashCow, Breeder Mortality).

4.2 Animal data processes

Paraway staff collect animal and property level data into a commercial software package called Animal Performance Software (APS), developed by Gallagher. At crushside, property staff use a SmartTSi (TSi) device integrated with a weigh scale and NLIS ear-tag reader. As animals are processed through a crush, their Electronic Identification (EID) is read and liveweight automatically recorded. Operators at crushside can then input data on various traits (wet/ dry status, pregnancy status, body condition score, fat depth, etc). The system can also be used to add notes and comments, can record treatments and procedures (as Activities), and can record various drafting or destination groupings as draft categories or events.

APS protocols use specific terms to describe various actions or data groups:

- Session: refers to the handling of a mob of cattle in a set of yards on a given day or days, i.e. cows yarded for pregnancy testing. Paraway protocols for session naming include:
    - Session type or event (transfer in/ out, agistment in/ out, sale, purchase, preg-testing, weight, fat-scanning, cull, branding and weaning)
    - Animal class
    - Source and destination property/ paddock (includes extrernal destinations such as live export, sale, feedlot etc)
- Life data: refers to information that is unlikely to change over the lifetime of the animal (breed, birthdate, gender, NLIS EID and tag number, origin PIC, colour, horn status)

- Activity: refers to some form of treatment or procedure (vaccination, HGP, dehorning, spaying, chemical treatments)
- Traits: represent the key animal-related measures that are to be stored in the APS/TSi. Key animal traits include liveweight, body condition score, pregnancy status and predicted month of calving, lactation status (wet/ dry). Additional traits may be recorded including dentition, horn status.

Animal-based measures are aggregated and combined, and then analysed to produce standardised production and performance measures. For reproductive performance measures as defined in the CashCow project are the standard. For liveweight measures, include liveweight at key times and average daily gain over time.

4.3 Current data flows

Individual properties maintain their own installations of APS software on the property. When animals are yarded and processed, new data are collected directly into the TSi at crushside (session data). Session data are then moved from the TSi into APS on a desktop computer at the property office. Session data are then merged into a property file that forms a record of animals on the property.

Updates and additional records of treatments, movements and other records can be added or modified on individual animals or blocks of animals at any time through either the TSI interface or the APS interface.

Periodically each property will send data files to a head office for processing, analysing and reporting using email, USB or other approaches. Head office staff receive files as CSV files and generally work on them in Excel. Data are cleaned to remove duplicates and obvious errors. There is variable (and occasionally considerable) updating of selected fields and then the data are restructured and combined. This work is done through a combination of manual manipulation, macros and the use of pivot-tables and formulae within Excel.

APS currently provides a record of those animals that were processed and where EID and animal traits were recorded. APS records do not necessarily provide an accurate count of all animals that may be expected to be in a paddock or on a property at a point in time. This was evident by comparing the number of animal records in APS files to separate livestock inventory records maintained in Microsoft Excel. Some summary performance measures require denominator data (number of cows retained, number of weaners produced and so on). These measures are not able to be automatically generated from aggregated APS records and must be sourced separately from livestock schedule records. As compliance improves, APS records may move to a more accurate representation of all animals.

Examples of updating and editing of fields include issues such as defining animal classes and age groups, adding reasons or descriptive names for various sessions, adding property names, adding or editing paddock names.

Cleaned and restructured data are then analysed in Excel to generate summary reports for various standardised performance measures, mostly associated with breeding performance and growth.

Reports are then circulated to property management and to other senior management staff within Paraway, and the parent company.

The current system is not sustainable in the longer term, and has a number of constraints and shortcomings associated with the use of Excel, and the ongoing need for manually controlled operations used to clean, combine, manipulate and analyse datasets.

4.3.1 Specific issues with reproductive data

Example data files from breeding herds were inspected, processed and analysed.

A number of minor data quality issues were identified including records with no relevant data, records with missing EID values (not able to be linked to an individual animal), duplicate records, implausible values and missing values on some fields. Many of these were able to be resolved using automated algorithms coded into the database. Problem records were able to be identified and prepared for download to allow detailed inspection and correction, and then re-submission to the database.

Estimation of CashCow performance measures such as P4M, require pregnancy status records on cows over successive years. Accurate assessment of annual lactation status is best achieved with two lactation status records in a year. Paraway records contained only a small proportion of animals with pregnancy status in successive years because data collection processes were new and compliance was still rising. These measures will become more useful as compliance rises over time.

Birthdate records were occasionally recorded as year, and in some records as a date reflecting early birth in a season (1/1/2014) or later birth (1/5/2014).

The primary value of birth date is to record the year of birth for assigning animals to age classes. A secondary and more detailed derived value may be to distinguish between animals born in the first half of the season vs those born in the second half of the season. It is not clear how operators may be choosing different birthdates within a year – presumably it may relate to whether a calf/weaner may have been born early vs late. More information is required on how birthdate is assessed and how a more detailed birth year record might be useful. For example, if there is value in distinguishing birth year by halves (20014_1, 2014_2 for first half and second half respectively), then the system can be used to analyse and report summary measures based on these distinctions. These distinctions may only be useful for weaners and joiners and then no longer need to be used.

4.3.2 Specific issues with growing data

Growing data was mainly based on liveweight. Relatively few growing animals had body condition score recorded. Many growing animals had been bred on a different property and then transferred to the growing property. In the lifetime APS files from the growing property, it was common for animal records to be missing lifetime data such as birthdate, breed, gender, etc.

Optimal value from growing data will require complete recordsets, including lifetime data, to allow information on age, gender, breed and property of origin to be included in analyses.

There were a number of challenges associated with liveweight data, including multiple measures on some animals that were close together in time, and erroneous records that are likely to be recording errors.

A number of rules were developed and applied based on common sense and preliminary screening of raw data. These included using multiple records that were more than 60 days apart to assess growth over time, and screening to identify unusual values to filter them out as likely errors. This may mean that liveweight measures were best used for cohort performance measures, and to understand achievable targets and thresholds. This will help in the management of individual animal decisions, by allowing individual animal weights to be compared to cohort or historic benchmarks and targets.

Decisions about the number of weighings per animal per year, and the timing of weighings will depend on a variety of factors. About one-third of animals in 2014 records had two or more weight measures (separated by 60+ days) in a year, and two-thirds had a single weight measure. It may be useful to generate two weight measures for each animal for each year: one early (April-June), and one late (Sept-Oct). This would allow repeatable assessment of within and between yearly weight measures and weight changes. However this would only be worthwhile if weight measures were used for meaningful decisions, i.e. had a real impact on animal management, and if the return on investment (labour and data collection time) was positive.

Walk-over-weigh (WOW) systems do offer an alternative for collection of liveweight values, but may present a different set of challenges concerning set, maintenance, calibration and validation that are beyond the scope of this project.

4.4 Discussion

At the time this project started, company staff were managing animal performance measures in multiple Excel files with manual checking, cleaning and aggregation and with analyses conducted using a variety of manual formulae, macros and pivot tables. These approaches were recognised as being problematic and not sustainable in the longer term.

The project timeframe and budget was not sufficient to allow development of a customised web-based system that would meet all data management and reporting needs now, and into the future, for the northern beef enterprises within Paraway.

A decision was made to adapt an existing web-based system that could be used by AusVet as a prototype to develop and test routines, and provide information to Paraway consistent with the project aim. It was expected that Paraway would at some time in the future, develop capacity for some form of database system to manage data from livestock enterprises.

A prototype web-based database (called AVHIS) was built by AusVet to allow development and testing of protocols and code for importing Paraway animal data and analyses designed to produce performance measures based largely on CashCow indices.

AVHIS was adapted from a fully functional database system developed and owned by AusVet for other purposes. Adapting this system for this project meant that we were able to avoid

all of the initial development of base structure and function, and could focus on functionality of direct practical application for this project.

The primary purpose of AVHIS was to allow development and testing of routines that could be applied time after time to facilitate the management of regular data flows in a consistent and verified way to check, clean, aggregate and analyse data, and produce defined reports with standard performance benchmarks.

These routines could then be incorporated into whatever future system Paraway may adopt or develop to manage their livestock data.

A secondary purpose was to consider whether AVHIS may form an interim solution for Paraway to manage animal level data and reporting, until a fully featured solution was developed and implemented.

We anticipated that AVHIS would not be suitable as a long-term solution because:

- it would likely require ongoing involvement of personnel with advanced expertise in R-coding, data management and database design and function (such as consultants from AusVet) to assist Paraway staff in managing the system and data flows.
- it is unlikely to be seen by property managers and junior staff as a suitable interface for encouraging property-level interaction with the system for data uploading and report generation.
- it is built on an underlying database platform that is now outdated and was considered unlikely to provide the flexibility to allow easy customisation, ad hoc querying, and capacity expansion over time.

Our experience in adapting AVHIS as an interim solution included:

- Importing, processing and analysing real data files exported from on-farm APS software (complete history files) through the AVHIS system including:
    - processing through R-code to complete data checking, re-shaping from wide to long format, removal of duplicate records, identification of possible problem/missing data and preparation for importing into AVHIS.
        - This step is code driven so can be documented and replicated in an auditable process
        - Currently this step requires direct involvement of an individual with expertise in R-code and database design and function (Dr Jenny Hutchison from AusVet developed the processes).
    - importing cleaned data into AVHIS
    - developing queries and analytical routines in AVHIS that can analyse data to produce summary tables and graphs on key performance measures, as required by Paraway.
        - **the initial focus was on the development of routines to provide reproductive performance measures (pregnancy rates, calving windows, P4M etc).**
        - **routines were then developed for dealing with weight data**, first to clean and aggregate data to produce a dataset suitable for analyses, and then **to analyse these data to produce summary measures of weight and ADG**.
- Outputs of key performance measures were compared to those obtained on the same APS import files by Ms Harriet Pugh (Macquarie) and were in very close agreement.

As this project neared completion Paraway were understood to be considering options for the development of a central data warehouse to manage data from all aspects of their agricultural operations, of which the northern beef enterprises form one component.

The learnings from this project including the examples of code used for data manipulation, analysis and reporting, would be expected to be useful in contributing to the design and functionality of a future Paraway system.

The existing software systems (Gallagher TSi and APS) currently used to collect and manage animal data appear to be associated with design constraints that may limit flexibility and ease of use at the crush-side interface, as well as constraining ease of movement of data records from APS to other systems.

Options for minimising the possible impacts of these constraints may include revisiting the design and approach to collecting crushside measures, as well as implementing automated (code-driven) approaches for moving data from APS into a centralised data repository, such as cleaning, problem-checking, aggregating, analysing and reporting. This is likely to be best achieved through a custom web system – see next section.

Standardised methods and protocols have been developed that define what measures are to be collected at crushside, and how data are to be moved into APS.

Our experience in exploring raw data suggests that property staff are improving in terms of compliance with protocols but there are ongoing problems with missing data.

In addition, protocols sometimes call for field names and data recording that are not necessarily conducive to collecting data in a way that makes subsequent data aggregation and analysis as easy as it could be. In some cases this may be because of TSi constraints.

There is a need for closer interaction between individuals with database design and analysis expertise, and those individuals with responsibility for handling animals and collecting data to drive joint development of an efficient, user-friendly crushside system..

Property staff responsible for collecting animal data appear to be largely spared the responsibility of ensuring data are complete and error free. Datasets are sent to head office and many errors, checks and corrections (including entry of additional data fields) are managed by head office staff. **This means that there is little incentive or opportunity for property-level staff to appreciate and correct their own errors, or improve processes over time.**

The current system has a reasonably long delay between crushside collection of data (representing property staff effort in data collection) and reporting back to property staff. **A system that has immediate feedback to the property staff on issues relating to possible errors and missing data, and provides rapid reporting on performance measures, is more likely to encourage compliance, improved performance, and engaged use of reports to guide decisions.** In our experience, if a system provides clear and immediate benefits to a staff member – in particular, if it makes their job easier to do – they will adopt it and use it eagerly. There is a big difference between doing something because it is 'part of the job' and choosing to do it because it makes work practices easier.

In the course of this project, **staff turnover in the corporate head office has interfered with progress, because corporate expertise has been lost and new staff have had to re-learn**

methods. On occasion new staff re-created approaches to solve problems, while unaware that methods had previously been developed and applied to solve the same issues. We expect that the move for Paraway Pastoral to Orange will help address these issues.

We propose that a web-based database will provide an optimal solution for Paraway.

The major benefits of a web-based system in the short term are **not related** to any potential vision of uploading data from the crush into the cloud, and having some form of analysis and reporting occur in real time to inform a decision about that animal before it is released from the crush. This vision may occur in the future, and is being advanced through current work on walk over weigh platforms, but it is still considered to be a research intensive area, and not ready for widespread practical deployment at scale.

The benefits of a web-based system are in two broad areas. One is that a centralised web-based system provides technical advantages – it is easier and more flexible to develop, implement and update/ change over time. Any changes or improvements are made centrally, and are immediately available across the system.

The second area is that user engagement and feedback can be greatly enhanced. This has a major, potentially positive impact on compliance with protocols and user learning and interaction. A user who collects data in the field and uploads it that night (or that day) can get immediate feedback on data quality and completeness, including lists of issues that can be improved, problem data to be checked, and reports on performance measures. This immediacy of feedback can be followed up by head office or management to reinforce the message. This approach will improve compliance.

A future solution for Paraway will be most effective if it has the following attributes:

- Crushside data collection is based on a mixture of automated data recording using pre-set defaults or automated recording (date, time, property, paddock, EID, weight, etc) and manual data entry for selected measures (pregnancy status, wet-dry, BCS etc);
- Data should be uploaded into a web-based repository as soon as possible:
    - at the end of a processing day/ period from the site office.
    - at crushside if web linkage is feasible – unlikely to be feasible for some time.
- Automated data cleaning and preliminary checking should be done on data upload, and immediate feedback given to property staff about missing/incomplete data and possible data errors. Rapid feedback will ensure that property staff have an opportunity to correct errors and add data to ensure complete records.
- Where possible, routine reports should be automated so that uploaded data can be analysed, and reports made available immediately. This will also help to ensure that property staff can get immediate access to reports and begin to realise value from effective and complete data uploads to ensure effective reports. Reports can be customised to meet different purposes (operational vs management or enterprise level).
- An important part of performance measures should be based on data collection and completeness to encourage compliance with policies.

Much of remote Australia has no, or very limited, internet access. Technical advances such as the recent launching of the Sky Muster™ satellite may improve internet availability, but anecdotal reports from regional users suggest that each time bandwidth and internet access is increased, services are rapidly overloaded by users inceasing their use of internet services.

In the long-term, it is expected that internet availability will increase, but in the mid-term, it is likely that regional access will be limited relative to urban areas. This means that real-time, crushside internet access is unlikely to be a practical option for remote cattle producers. Data uploads to a central repository that is web-mounted are, therefore, most likely to be done at a homestead or property office that has internet access. Even then, particular properties may require individual technical approaches to deal with limited bandwidth.

Remote, northern cattle enterprises also tend to yard cattle infrequently, and may only have one, or a small number of measurement opportunities, where cattle are handled and measurements collected or entered. These constraints limit what can be collected, and in turn, what secondary or derived measures can be calculated.

All of these constraints are likely to mean that it is not practical to aim for any system that:

- attempts to collect some form of measurement from an animal in remote crush;
- upload individual animal measurements to a central web database for assessment and reporting and,
- Use interpretive outputs to guide decisions about that animal while it is still in the crush.

This means that for the immediate future, technical advances in crushside management of data may have little impact on a decision about an individual animal standing in the crush.

Technical advances in data management, and end-of-day uploading to a central database, have the potential to improve data quality and completeness, and improve mob, property and enterprise reporting, and business management.

Being able to upload collected data soon after the end of a session (end of the day for example), allows automated data cleaning and reporting routines to be done immediately with feedback to the user. This is an excellent way of improving compliance and data completeness because it provides useful feedback to users soon after they have collected data. Some of the data problems we encountered, such as paddock or mob details, dates, animal age categories, purpose for handling etc., may all be able to be updated. Other data issues such as missing data and possible data errors, may not be able to be corrected if animals have been let go from the yards, but feedback while the experience is fresh in the mind of remote staff increases the likelihood of improved compliance for future events.

Synchronising a central web database with a local crushside device can allow increased provision of crushside analytical and reporting options through local device capacity. This may allow some level of immediate reporting of real-time data (measurement collected now on one animal in the crush), combined with historic data measures for an individual animal, or mob/cohort measures for the group to date.

4.5 Conclusions and recommendations

Optimal management of animal performance and inventory records can be delivered through a web-based database.

Automated algorithms can be incorporated into this system to allow efficient and effective transfer of data from crushside devices or desktop software such as APS. Routines can incorporate data checking and cleaning, as well as identification of problematic records for further manual checking.

Cleaned and aggregated data can be analysed and reported.

Analyses are only as good as the data upon which they are based.

Individual animal measures rely on animal identification. Electronically read NLIS tags provide a simple way to automatically record unique animal identification values, and facilitate automated linking of multiple measures from the same animal. NLIS tags may be lost over time or suffer from read failures. A visual tag provides a useful backup that can prevent data loss in the event that an NLIS tag is lost.

Many of the metrics and performance measures used for management decisions rely on repeated measurements performed on the same animal (for example, average daily gain, or pregnant within four months). Failure to obtain repeated data points for the majority of animals in a cohort can result in decisions based on a non-representative subset of animals.

We recommend that consideration be given to the development of web-based, modular database systems that provide scaleable, flexible and secure repositories for animal data, and that incorporate data checking, analytical, and reporting routines.

This report provides various suggestions for the characteristics and attributes needed for such systems.