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Upgrade of LATSA software

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Abstract

Version 2 of the Livestock Air Transport Safety Assessment (LATSA) software has the ability to generate key physiological data (heat, moisture and carbon dioxide) for a diverse range of the livestock (cattle, sheep and goats) that might be transported on aircraft in Australia. The software caters for combinations of species, animal liveweight and crate configuration. The program provides estimates of environmental hold conditions in the freighter and passenger aircraft normally employed in transporting livestock in or out of Australia. It also provides values for parameters that are important in assessing the compliance of a consignment against the Australian Standards for the Export of Livestock (ASEL).

Executive summary

Version 2.0 of the Live Air Transport Safety Assessment (LATSA) software has been developed to assess the ventilation capacity of aircraft and their ability to safely dissipate generated heat, moisture and carbon dioxide. It is important to note that LATSA 2.0 models several complex systems and has been designed on a conservative basis. In many of its calculations LATSA 2.0 assumes a worse than average case scenario for constants and variables. As a result the values predicted through use of the program will in most cases, exceed what is likely to occur in practice. While this approach may over estimate temperature, humidity and carbon dioxide limits in aircraft holds in-flight, it assists exporters by clearly identifying marginal load cases. In doing so it should provide a level of confidence (including some degree of safety) on which the regulating bodies can rely.

Version 2 of LATSA is structured to meet many sometimes conflicting constraints. There is both a need for expanded storage of information and a generic simplicity in presentation and operation of the program. The program attempts to cater for both situations. The objectives of this project have expanded the table structure and computational requirements of the original LATSA software. The structure and storage requirement of both the administrative and participant areas of the database has increased at least four fold.

Version 2 of LATSA now incorporates extensive algorithms for both animal physiological factors and ventilation computations. The SQL database which forms the basis of the system is supported by source code written in ASP.NET (VB.Net). The interface is HTML based and would be familiar to almost all participants who operate in an internet based environment.

The upgrade of the program now presents the heat, moisture and carbon dioxide outputs for any single consignment of cattle, sheep and goats and any combination of these livestock. It then uses psychometric calculations together with publically available aircraft ventilation data to determine if the aircraft has the basic capability to transport the consignment without incident. Version 2 of LATSA is positioned to provide a worse than average case, meaning that if the program provides a successful result the in-flight conditions will be controllable. If the program presents a poor or bad result it is quite likely that there will be severe consequences for the animals travelling on the aircraft.

In the case of marginal or poor results from the program, it is expected that the exporter would commence discussions with the aircraft carrier to determine alternative loading conditions. While exporters are generally expert in livestock management and transportation they are not aircraft engineers and cannot be expected to have intimate knowledge of aircraft design. However, LATSA is designed to assist exporters to understand the constraints and to ask the right questions when load conditions appear unsatisfactory. For example, AQIS have concerns regarding the transport of livestock in lower holds. This concern has developed due to the dramatic variation in the ventilation capacity of lower forward and aft holds. This variation extends from very high capacity to no ventilation whatsoever. LATSA has capacity to store and utilise this and other information as it becomes available, however, administration of the database is necessary to ensure that information is accurate over time.

Version 2 of LATSA provides a comprehensive tool which guides exporters in the knowledge required to safely transport livestock on various models of aircraft. In most cases exporters rely heavily on the capabilities of the carriers who should have more knowledge and better tools available to them. In practice the information required to make a definitive determination regarding Environmental Control Systems (ECS) capability is an engineering exercise through the use of various aircraft manuals, manufacturer provided systems and discussions with engineering staff. Little if any of this information is available to parties outside the aircraft

industry and in particular appears only available to aircraft manufacturers, owners and selected service staff.

Contents

1 Introduction

This project developed from a need to upgrade and expand Version 1 the Livestock Air Transport Safety Assessment (LATSA) software. LATSA version 1 provided a preliminary assessment of the ventilation suitability of proposed consignments of livestock for transport in specific aircraft holds. The software was a simple, standalone tool designed to validate the conditions for which a specific set of livestock type could be transported by air. It was developed following a need to simplify the issues relating to Environmental Control Systems (ECS) on various models of aircraft when transporting livestock by air.

The Australian Quarantine and Inspection Service (AQIS) is the regulating body assigned to control the export of animals from Australia by any means. This duty extends to the health and well being of exported livestock. The primary welfare issues for this and the former project under which Version 1 of LATSA was developed, include:

- Stocking density; and,
- Aircraft ventilation capability and capacity.

It was determined that the outcomes of earlier projects relating to air transportation of livestock, in particular industry regulation of stock crate supply, should be incorporated into the database. This would allow a centralised storage point for most of the important data relating to air transportation of livestock. This centralisation could provide a mechanism by which the industry as a whole could improve its performance over time.

As a result of active participation of industry members, a set of objectives was developed on which to base the upgrade of the LATSA system. These objectives would dramatically extend the capability of the software to enable user's greater flexibility and improve uptake of the system.

2 Project objectives

2.1 Terms of Reference

In various industry meetings participants determined that data supporting animal and ventilation parameters within Version 1 of LATSA needed to be validated in addition to the expansion of the LATSA software to cope the multitude of load configurations. These discussions resulted in the development of the following objectives:

- *Review the existing LATSA software and recommend software improvements;*
- *Validate and amend if necessary the biological parameters used in the current model which have been used to produce the physiological data for cattle, sheep and goats;*
- *Extrapolate the physiological data to include all weights for cattle, sheep and goats;*
- *Upgrade the existing software to perform the following calculations:*

a. Calculate stocking densities based on ASEL [Australian Standards for the Export of Livestock] for consignments of multiple species and liveweights;

b. For the calculated stocking densities calculate total area and payload required to fit a desired consignment to ASEL standards;

c. Include a database of approved crate designs with floor area specifications for each deck (single, double, triple) and total floor area available for each crate;

d. Be able to load known classes and weights of animals to an elected type of crate,

e. Be able to fill known number of crates with different species and average weights of animals to ASEL standards.

- *For all the functions listed above ensure that ventilation on aircraft can cope with the requested ASEL stocking density. Should aircraft ventilation be insufficient to cope with any of the requested ASEL stocking densities, recalculate stocking densities to ensure adequate ventilation for livestock;*
- *Undertake industry consultation with information providers and nominated software users to ensure software capabilities match industry expectations;*
- *To design the software so it can be accessed through the World Wide Web with suitable security.*

Advice provided by LiveCorp and MLA was that for the purposes of this particular project, the assessment of the adequacy of aircraft ventilation was to be limited to a steady state result in level flight and continue to utilise the same on ground time constraints built into version 1 of LATSA. Modelling of conditions during ascent and descent, and while the aircraft is on the tarmac, may be considered in subsequent reviews and upgrades.

3 Methodology

3.1 Project stages

The staged approach adopted in undertaking this project is summarised in Figure 1.

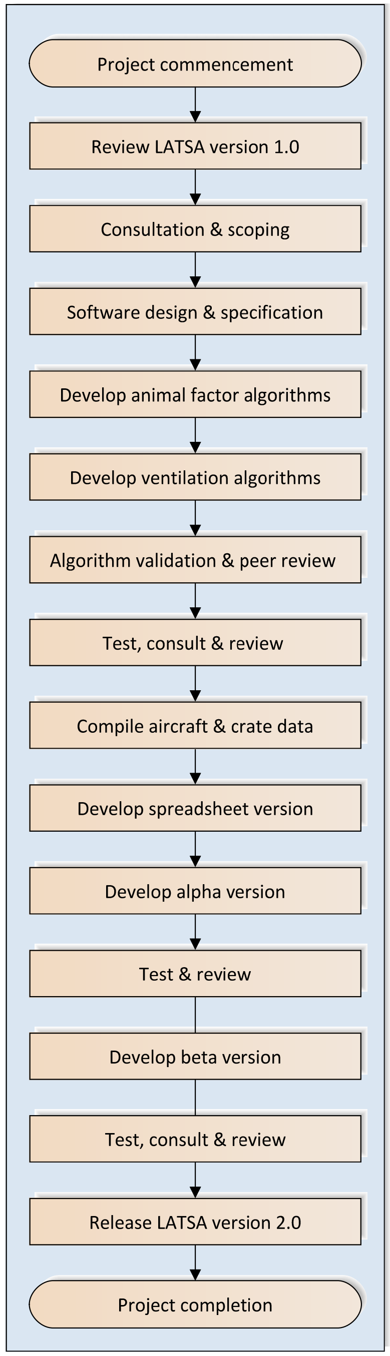

Figure 1: Flowchart showing principal project stages

3.2 Literature reviews

A literature review was undertaken to determine the most appropriate algorithms for the calculation of animal physiological parameters and the interaction with aircraft ventilation systems. The methodology adopted for this component of the project involved:

- *A review of the current state of scientific knowledge in respect to the relevant physiological factors;*
- *Comparison of predictive relationships for physiological factors with those used in the version 1 of the LATSA software;*
- *Identification of suitable 'animal factor' algorithms for computing the required values for physiological factors applicable to all weights, ages and classes of cattle, sheep and goats;*
- *A review of the methodologies currently employed or potentially available for predicting the environmental conditions in aircraft ;*
- *Comparison of predictive relationships for environmental factors with those used in Version 1 of the LATSA software; and*
- *Identification of suitable 'aircraft ventilation' algorithms for predicting the values for key environmental variables during level flight (in cruise mode).*

The key references consulted during this process include the following:

- *Climitization of Animal Houses (CIGR, 1992 & 2002);*
- *EP270.5 Design of Ventilation Systems for Poultry and Livestock Shelters (ASAE, 1986);*
- *Live Animal Regulations (IATA, 2009a);*
- *Nutrient Requirements of Domesticated Ruminants (Freer et al., 2007);*
- *Perishable Cargo Regulations (IATA, 2009b);*
- *SAE AIR1600: Animal environment in cargo holds (SAE Aerospace, 2003); and*
- *Standards for the Microclimate inside Animal Transport Road Vehicles (SCAHAW, 1999).*

A more comprehensive bibliography is provided in Section 8 of this report.

It should be noted that the International Air Transport Association (IATA) regulations (IATA, 2009a & 2009b) treat *SAE AIR1600* as the primary reference in these matters.

This literature review provided a series of algorithms which are presented and discussed throughout Section 4 of this report.

3.3 Software design and specification

A review of version 1 of LATSA established that the main areas requiring improvement were those previously identified in the terms of reference for this project (refer Section 2, above). This was reinforced by a consultative meeting held with MLA/LiveCorp staff and industry representatives in Brisbane on 16 February 2010.

In the review it was found that version 1 of LATSA consisted of hard written data tables for specific livestock types or classes together with output values. Across all species, the available livestock types were limited to less than ten selections. The number of selections was consistent with *SAE AIR1600*. The physiological data appear to be drawn from graph presented in literature reviewed during the originating project, and so were restricted to the few animal types represented in that material.

While version 1 of LATSA ensured that a process was in place to guide exporters (participants) through the system and provide a definitive answer, it does not have the ability to match all consigned loads. In addition the software does not provide any computational analysis of either animal physiological parameters or aircraft ventilation.

Version 1 of LATSA contained aircraft model and general capacity data but the linkages between operators and aircraft were incomplete in the basic version. The expectation was that these were to be manually updated by users or loaded via a software update. The use of lower holds, deemed important by AQIS was dealt with via a simple yes/no checkbox and the assignment of livestock to various aircraft holds was not available.

Through the review of version 1 of LATSA, and a review of the objectives, it was determined that software needed to be reconstructed, rather than simply modified. A small portion of the original Microsoft® Access database, principally the aircraft, operator and airport tables, was capable of being extracted and expanded to include all the data required to fulfil the project objectives.

Version 2 of LATSA was required to be internet based. The decision was made to construct the database in an SQL environment, which required placement on an SQL server. The user interface has been written in Microsoft® Visual Studio 2, and presents itself in a similar fashion to many HTML based internet sites.

The computation analysis forming the backbone of the system is written in ASP.NET (VB Net). The intellectual property associated with the source code remains the property of Meat and Livestock Australia Limited.

The database tables have extensive inter-relationships. Many of the tables and fields are more extensive than the basic requirements of the project objectives. A decision was taken to provide some ‘future proofing’, by providing the ability to collect and store additional information, which could be utilised in future upgrades of the software. Coupled with the methodology and documentation of the source code, this will ensure that minor upgrades of the software are cost effective.

The source code encapsulates all the calculations referred to in this report. Computational results are not hard written to database table field. This allows real time correction of results when changes are made to source data (*i.e*. that entered by the user through the consignment window).

There are two access points to the data tables. Firstly, administrator access allows the system operator to add new data for aircraft, operators, crates, users and other information, which is not accessible to the general user. Through normal business process controls, this restricts the manipulation of important information such as hold ventilation data and crate details, much of which has a very significant impact on the results obtained in the general user area of the software. Secondly, the general user (participant or exporter) has access to the Consignment pages of the software. This allows the exporter to load all consignment information; assign crates, animals and aircraft holds through load lines; obtain results based on each hold utilised; and extract overall data such as flight time and total weight. In addition, the exporter can retrieve general consignment information and the required data for exportation documentation.

The field linkages within the table structure allow for selection of variables, such as operators, aircraft, holds, manufacturers, crates and animals in a related manner. Where data is not linked by the System Administrator, it cannot be selected. As an example, where a crate fits only one aircraft hold (*e.g*. Boeing 747-400 main hold) it cannot be selected in any other aircraft or hold – it will simply not be available for selection (*e.g*. A340-300 main hold or Boeing 747-400 lower forward hold).

In addition to field linkages, there are compliance fields within the operator, aircraft and hold tables, which restrict the use of the appropriate data if it is deemed non-compliant by industry or the regulating body. This compliance check may be as specific as one hold of one plane for one operator. Again, where data is non-compliant, it will simply not appear in the selection list.

The default for all data selection is off, meaning that no selections will appear unless they have been setup by the System Administrator.

3.4 Compilation of aircraft and crate data

3.4.1 Aircraft data

No comprehensive set of data relating to aircraft heating, ventilating and air conditioning (HVAC) systems could be located in the public domain, and some difficulties were experienced trying to source the required data from aircraft manufacturers or operators. While the report associated with version 1 of LATSA does include a quantity of HVAC data, the dataset does not include all the variables required to undertake the calculations used in version 2. Consequently, it was necessary to supplement the existing data with information that could be obtained from aircraft manufacturer's published values (where available), values in IATA standards, and other sources. During this process the opportunity was taken to cross-check the version 1 data with other sources. If any anomalies were identified, these were investigated further and what was judged to be the best available data, whether it was the version 1 values or others, was used in version 2. A summary of the Aircraft and Hold Tables as at the time of this report can be found in Section 9.2 Appendix 2 – Aircraft Data Tables used in version 2 of LATSA.

Historically, aircraft specifications, including those pertaining to HVAC systems, have used United States customary units (US units) rather than *Système International* (SI) units. However, both US and SI units are now being used in these publications. As a precursor to developing the aircraft datasets used in version 2 of LATSA, all data using US units were converted to SI unit values. This included the US unit datasets in version 1 of LATSA.

3.4.2 Crate data

Much of the upgrade to LATSA is based on the issues of industry regulation of stock crates, the ability to place known numbers of crates in aircraft hold and the assignment of stock to crates to meet ASEL standards. In order to load and calculate nominated stocking densities, and compare these to ASEL, the software is required to store a significant amount of data relating to identifiable stock crates.

The data table structure includes several tables relating to the following:

- Crate Manufacturer's detail;
- Crates details including certification information;
- Tier details; and
- Hold Information.

While the information is sufficiently detailed to allow the objectives of stock assignment and stocking density calculations to be met, no manufacturer has been required to provide proprietary information that would not normally be discovered through the general use of the product. However, manufacturers and stock crates will be individually identifiable through the use of the software. This has both positive and negative consequences for all parties, but this issue is not within the terms of reference of this project.

In order to meet one objective of the project, the crate manufacturer and crate details tables include fields associated with manufacturer registration and crate certification respectively. While this information is present and is reported on output documents, it does not preclude the use of uncertified crates and unregistered manufacturers.

Table links allow participants to consign specific loads of animals in specific crates to a hold in a nominated aircraft. This versatility meets the objectives of the project, however, it should be noted that participants may be required to develop additional knowledge of the hold assignment in order to utilise the system effectively. While this may be seen as a constraint, it is viewed as a potential requirement in meeting regulatory demands both now and in the future. A basic participant knowledge of ventilation constraints and hold structures is required in order to operate LATSA V2.0 effectively.

The number, size and configuration of crates placed in an aircraft hold are important in the calculation of volumetric data and subsequent air velocity and mixing ratios. The latter have a direct impact on the primary considerations of this project. The internal floor area of each tier and the number of stock are utilised in calculating the actual stocking density. This result is compared to the ASEL density, which the program develops from regression equations based on the ASEL standard (see Section 4.1.4).

The addition of crate data associated with consignment details can provide more transparency if it is provided within export documentation. This additional information may provide a higher degree of confidence on the part of the regulatory body (i.e. that the industry can identify and trace issues relating to a shipment that is within its control).

4 Results and discussion

4.1 Terminology, concepts and assumptions

4.1.1 Hold nomenclature

Figure 2 illustrates the names applied to aircraft holds in this report.

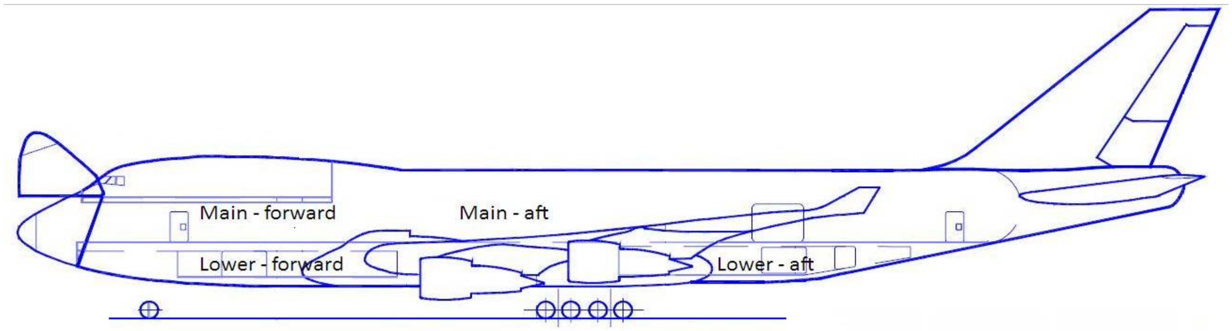

Figure 2: Hold nomenclature used in this report (B747-400 Freighter silhouette ©Boeing Commercial Airplane Company, 2002)

In passenger aircraft the main hold is fully utilised for passenger accommodation. In 'combi' configurations, the main hold is partly utilised for passenger accommodation, allowing 'cargo only' access to the remainder of the hold. Livestock might still be carried in the lower holds on passenger aircraft, or in the freight section of the main hold of combi aircraft, provided that adequate ventilation segregation is installed.

Not all lower holds or all parts of lower holds have the ability to carry the containerised or palletised Unit Load Devices (ULDs) normally required for livestock transport. Similarly not all lower holds on all aircraft are suitably ventilated for the transport of livestock – although this limitation generally applies more to older aircraft.

As indicated in Figure 2, in larger and multi-decked aircraft such as the Boeing B747, the main deck can consist of forward and aft zones, and ventilation may be delivered to these two zones under different regimes. However, these differences are not directly addressed in the IATA *Live Animal Regulations* or *SAE AIR1600.* While there may be some variation in air flow dynamics within the main hold this has not been taken into account in the context of the relative precision of the calculations presented in this report. In any future development and refinement of the LATSA software, consideration might be given to modelling the zonal differences in aircraft holds.

4.1.2 Livestock crates

Cattle, sheep, goats and camelids[1] being exported from Australia are normally transported in single-use containers, generally made of timber, plywood and/or fibreboard. These containers can be referred to by various names (*e.g.* crates, pens, boxes, stalls, *etc*). However, to be consistent with the terminology commonly applied in the Australian livestock exporting industry, these containers are referred to, both in this document and LATSA, as *crates*.

[1] Chiefly llama or alpaca in this instance

To facilitate standardised handling and loading on aircraft, the external dimensions (width, length, height, profile, *etc*.) of livestock crates normally correspond to those of one of the standard ULDs used for air freight. Crates are designed to fit on standardised aircraft pallets (one type of ULD). These pallets are relatively thin and manufactured from aluminium to standard designs detailed in NAS 3610 – 1990. The external dimensions of most, but not all, livestock crates currently manufactured in Australia correspond to those of a PMC flat pallet ULD (also known as a P1P or LD-7). The designation of PMC can be found in Chapter 4 of the IATA ULD Technical Manual and refers to P = Pallet, M = 2,438 x 3,175mm (96 x 125 in) and C = the restraint system in our case a net system. Version 2 of LATSA includes a database of standard crates available from Australian crate manufacturers and export agents. These crates may in future also be certified as suitable for the purpose (refer MLA Project W-LIV-0261). Version 2 of LATSA has been design to store the details of all certified (and uncertified) crates.

4.1.3 Tiers

When juvenile or smaller-framed adult livestock (*e.g*. sheep and goats) are being transported, it is possible to use what can be described as multi-level, multi-tier, multi-floor or multi-deck crates, and still remain within the relevant loading height limitations of aircraft holds. The term *tier* will be used in this document when referring to these crates. Figure 3 shows an example of a 2-tier timber crate (without the entry door in place).

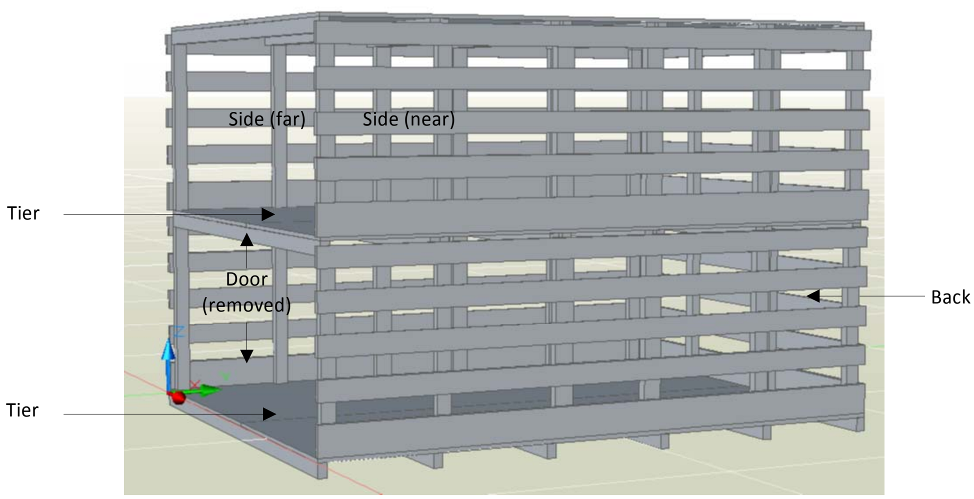

Figure 3: Example of a 2-tier crate used for aircraft transport of livestock

4.1.4 Stocking density

Stocking density is considered here to be the total useable floor or tier space available to the animals being transported on each tier, expressed on a *per capita* or per animal basis (*i.e*. expressed in units of m²/head). With reference to Figure 3 (above), the useable area considered in version 2 of LATSA is derived from the internal dimensions of the crate (*i.e*. the minimum horizontal distances between the opposite, innermost members of the vertical sides or ends of the crate on each tier). Where the vertical profile of tall, multi-tier crates has been shaped to follow the contour of the aircraft hold, further reductions in useable tier area may occur – refer ASEL standards for details of applicable reductions.

To accommodate the project requirement that version 2 of LATSA be able to calculate allowable stocking densities for all species of interest and for all likely animal liveweights, the tabulated maximum stocking densities in the ASEL standards were analysed to produce the regression equations listed in Table 1. In all three cases, the coefficient of determination (r^2) values for the regression equations are effectively unity (*i.e*. the three equations explain all the variation in the tabulated data).

Table 1: Regression equations used to calculate maximum stocking densities for animals of various liveweights allowed under ASEL

Species	Stocking density (m²/head)		
Cattle & camelids	$d = 0.002119 \times LWT + 0.2133$	$r^2 > 0.999$	**Equation 1**
Sheep	$d = 0.004236 \times LWT + 0.0615$	$r^2 > 0.999$	**Equation 2**
Goats	$d = 0.004800 \times LWT + 0.0210$	$r^2 > 0.999$	**Equation 3**

Where: *d* = stocking density (m²/head); and,
LWT = animal liveweight (kg).

4.1.5 Heat

Heat is a form of energy that can remain stationary in a closed, insulated system or be transferred between two bodies or connected systems and will naturally flow from a body or system at higher temperature to another at a lower temperature. This flow happens irrespective of whether the bodies are animate or inanimate. Importantly, any flow of heat energy in the reverse direction, against the natural trend, will necessitate work – in the context of physics – being done. The units applicable to a flow of heat energy are the Watt (W). A Watt is equivalent to a Joule per sec (J/s).

Heat can be considered to have two components:

- *Sensible heat; and*
- *Latent heat.*

4.1.6 Sensible heat

Sensible heat is the heat able to be 'sensed' by humans. It is that proportion of total heat associated with a change in temperature.

4.1.7 Latent heat

Latent heat is 'hidden' heat, which is not sensed directly by humans. It is the component of total heat in a system associated with a change of state (such as occurs in evaporation, vaporisation, sublimation, condensation, *etc*.).

4.1.8 Total heat

Total heat is the sum of the component sensible and latent heat, and can be expressed as:

$$\phi_{tot} = \phi_{sen} + \phi_{lat}$$

Equation 4

Where: ϕ_{tot} = total heat;
ϕ_{sen} = sensible heat; and
ϕ_{lat} = latent heat.

In general, if a surface is dry, energy will be intrinsically lost (or gained) in the form of sensible heat. If a surface is wet, energy can be used to drive evaporation (provided evaporation is possible), and will therefore be lost as latent heat. If a surface is neither completely wet nor completely dry, such as the typical case for the skin of an animal, energy is normally lost as a combination of sensible and latent heat.

4.1.9 Homeothermy

Homeothermic animals attempt to maintain a constant core body temperature irrespective of the environmental conditions the animal is exposed to. This ability is involuntary. However, the efficiency of the process is neither complete nor uniform across all species, ages, classes and conditions of homeothermic animals.

Figure 4 illustrates the thermal interactions between an animal and the environment within an aircraft hold. These interactions represent those involved in the animal attempting to maintain a constant core body temperature (*i.e*. homeothermy). The normal mechanisms for heat transfer in such circumstances are radiation, convection and conduction (*i.e*. sensible heat), and evaporation[2] (*i.e*. latent heat).

[2] Other forms of latent heat transfer, such as condensation, sublimation and deposition (icing) are possible, but less likely to a common occurrence.

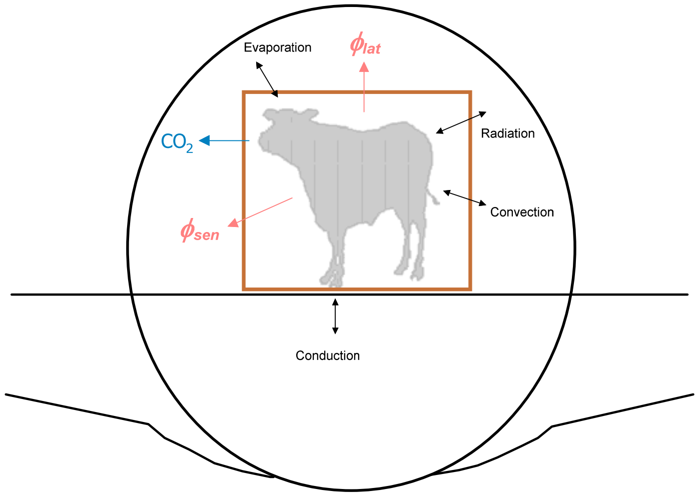

Figure 4: Diagrammatic representation of the interaction between a transported animal and the environment in an aircraft hold

Importantly, the flow of energy is not uni-directional, and depending on environmental conditions may involve the animal not simply dissipating, but also assimilating some energy. For example, heat will be gained by radiation or conduction, rather than lost, if an animal's surroundings (*e.g.* the aircraft hull) are hotter than the outside surface (skin) of the animal.

4.1.10 Effects of temperature & humidity on heat transfer

By way of example the observed effects of ambient air temperature and relative humidity on total, sensible and latent heat transfers in an experiment involving Ayrshire bull claves are depicted in Figure 5 (ASAE, 1986).

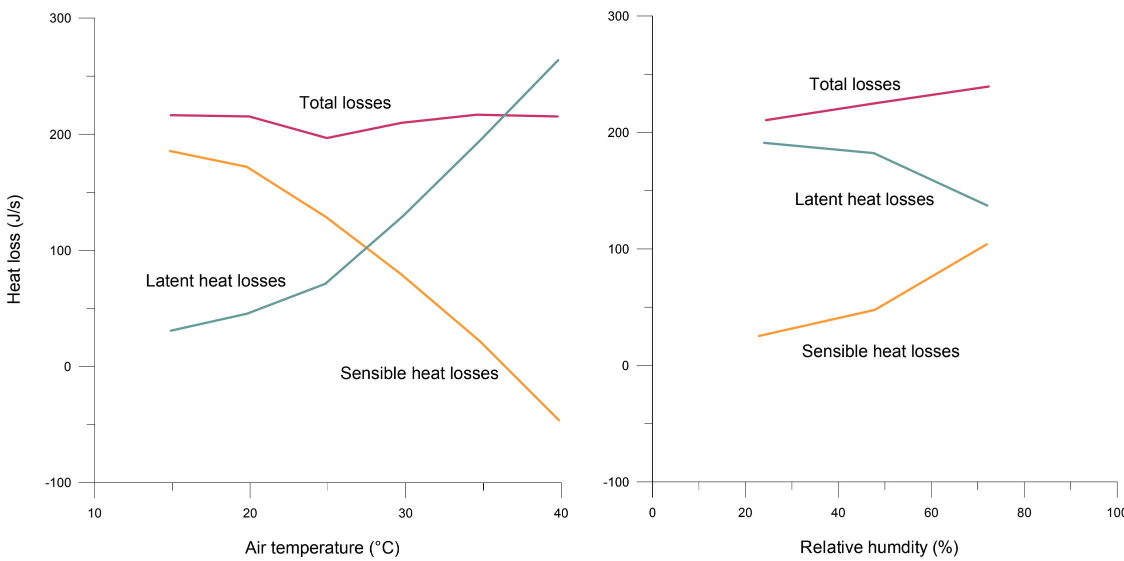

Figure 5: Effect of temperature on heat loss in three 6 – 12 month old Ayrshire bull calves, where vapour pressure was 1.066 KPa and dewpoint 8°C, and the effect of humidity on heat loss in three 6 – 12 month old Ayrshire bull calves, where air temperature was 35°C (redrawn from ASAE, 1986)

While the magnitude of the total sensible and latent heat losses reported here are specific to the Ayrshire calves used in the subject experiment, due to the degree of commonality in the physiological regulation mechanisms involved, not entirely dissimilar trends are likely to be seen in other ages and species of mammalian (homeotherm) livestock.

The following are noteworthy in respect to Figure 5:

- *Total heat losses were relatively uniform – although not entirely so – under the temperature and humidity conditions experienced in the subject experiments;*
- *When conditions aside from ambient temperature were held constant, sensible heat losses decreased and latent heat losses increased with increases in temperature;*
- *When the temperature was 35°C, and conditions other than humidity were held constant, sensible heat losses increased and latent heat losses decreased with increases in relative humidity;*
- *The experiments did not explore the potentially contrary effects on sensible and latent heat losses that may result from concurrent increases or decreases in temperature and relative humidity;*
- *The experiments did not evaluate the effects of air speed in the animal's environment; and*
- *Potential complicating factors such as activity levels, degree of acclimatisation, body condition, dietary energy intake, growth rates etc., were not explicitly considered.*

4.1.11 Thermoneutrality

Homeothermic animals, such as domestic ruminants, need to maintain their core body temperature within the range of 38 to 39°C to allow vital physiological processes to take place. This core body temperature is maintained by a combination of metabolic activity and certain physiological and behavioural responses (Freer *et al.*, 2007 and Hillman, 2009).

The range of environmental conditions over which an animal can maintain its core body temperature with minimal thermoregulatory effort (*i.e*. thermoneutral conditions) is finite. Thermoneutral conditions are commonly depicted as a distinct 'thermoneutral zone', bound at its upper and lower limits by what are generally termed the upper and lower critical temperatures, or *UCT* and *LCT* (refer CIGR 1992; CIGR 2002; Freer 2007 and Hillman, 2009). Outside of these temperature limits, the animal notionally begins to be exposed to heat and cold stress respectively[3].

Heat production is likely to increase due to exposure to both heat and cold stress – which can be somewhat counterproductive in the case of heat stress. Ongoing exposure to heat or cold stress will result in hyperthermia or hypothermia respectively, and without any respite, may ultimately result in death. Where there is regular or ongoing exposure to moderately stressful conditions, animals do have the capacity to acclimatise or adapt to those conditions (*e.g*. animals from tropical areas might have a higher UCT than those from more temperate areas).

[3] An alternative concept to that of a thermoneutral zone bound by a UCT and a LCT is one of a *biologically optimum temperate*, where an animal is, on average, under the least amount of thermal stress (refer Hillman, 2009). Such a temperature would be intermediate between a UCT and LCT. By definition, thermal stress would progressively increase at temperatures above and below the biologically optimum. Again such a temperature will not be a constant, varying with health, growth rate, productive performance, *etc.*

Figure 6 provides a classical representation of the conceptual relationship between heat production, a thermoneutral zone and upper and lower critical temperatures. In practice this relationship is more complex than Figure 6 suggests – particularly in regard to heat stress. However, within the context of this review, the relationship depicted is reasonably sound.

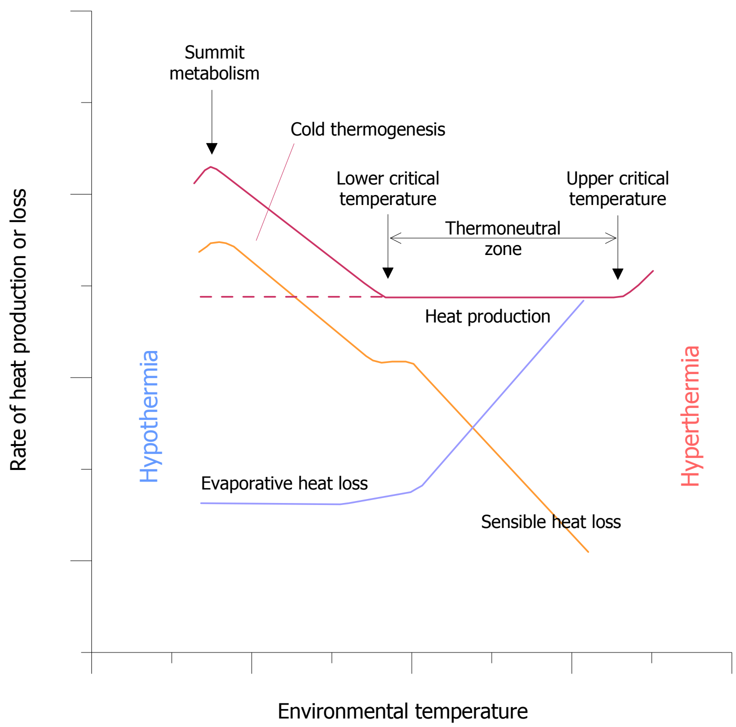

Figure 6: Notional effects of environmental temperature on thermoregulation in livestock (adapted from Freer *et al.*, 2007)

Within the thermoneutral zone in Figure 6, the relationship between the total, sensible and latent heat produced by an animal is analogous to that depicted in the left-hand graph in Figure 5 (page 20), with sensible heat losses decreasing and latent heat losses increasing as the ambient temperature progressively increases.

A major objective in managing the environment in an aircraft hold used to transport livestock must then be to minimise the risk of the animals being exposed to unnecessary thermal stress. Hence, that environment should ideally be kept within the thermoneutral zone of the transported animals. However, neither upper nor lower critical temperatures can be represented by a fixed value – this is indicated by the lack of a defined numerical scale on the *x*-axis in Figure 6. The relevant values for both temperatures vary with a diverse range of factors including:

- *Species and genotype;*
- *Age;*
- *Liveweight;*
- *Growth rate;*
- *Feed and energy intake;*
- *Stage of lactation;*
- *Stage of gestation;*

- *Depth of coat or fleece;*
- *Skin wetness and humidity;*
- *Air speed (environmental); and*
- *Acclimatisation.*

4.1.12 Critical temperatures

Despite its depiction as a well-defined, discrete point in Figure 6 (above), there is no unequivocal physiological definition of the temperature representing the upper critical temperature (UCT). However, one widely accepted definition is that of the IUPS Thermal Commission (2001), which is:

> *'The ambient temperature above which the rate of evaporative heat loss in a resting thermo-regulating animal must be increased (e.g. by thermal tachypnoea[4] or by thermal sweating), to maintain a thermal balance'*

Other definitions of UCT typically relate to it being the temperature at which an increase is observed in metabolic heat production as a result of the muscular expenditure involved in panting (*i.e*. the upwards inflection point in the red plotline on the right-hand side of Figure 6). However, while an observable increase in metabolic heat production as panting commences is common, it is not necessarily a universal characteristic of endothermic animals[5] (see Hillman, 2009).

As ambient temperatures drop below the lower critical temperature (LCT), there is a compensatory increase in the rate of metabolic heat production, principally as a result of shivering and/or non shivering thermogenesis. Any increase in metabolic activity has physiological limits, and can neither be sustained indefinitely nor always be sufficient to compensate entirely for the cold conditions. Behavioural changes such as huddling or adopting curled lying positions, which minimise the exposed surface area from which radiative transfers can occur, may be adopted in an attempt to reduce heat losses, provided that any physical constraints (*e.g*. stocking density) permit such activity. In an increasingly cold environment, shivering and non-shivering thermogenesis will, in time, fail to have a sufficient compensatory effect, and core body temperature will begin to drop. Eventually hypothermia will set in. Again, in the absence of any timely respite, death will ultimately occur.

4.1.13 Respiratory quotient

Metabolic activity results in an animal consuming atmospheric oxygen (O_2) and respiring carbon dioxide (CO_2). The respiratory quotient (RQ) is the ratio of the volume of CO_2 eliminated, to the volume of O_2 consumed, and varies with the organic substrates (carbohydrates, proteins, fats, *etc*.) being metabolised. The following stoichiometric equations are recognised mechanisms for the metabolism of glucose ($C_6H_{12}O_6$) and a fat ($C_{51}H_{98}O_6$), and depict how the proportions of O_2 consumed and CO_2 generated vary with the substrate being metabolised[6].

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[4] Unusually fast breathing (*i.e*. panting) to enhance latent heat loss from the respiratory tract

[5] Mammalian and avian animals, including livestock, that maintain their relatively high body temperatures by metabolic heat production

[6] Numerous texts will yield quite similar examples of these metabolic mechanisms and they are used here to illustrate the production of H_2O in the form of vapour and CO_2 through the metabolism of various organic products.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2.82\ \mathrm{MJ}$$
$$C_{51}H_{98}O_6 + 71.5O_2 \rightarrow 51CO_2 + 49H_2O + 32\ \mathrm{MJ}$$

The respiratory quotient (RQ) is 1.0 for glucose (6 moles O_2:6 moles CO_2), and around 0.7 for fats (0.71 for $C_{51}H_{98}O_6$ in the above example). The RQ values for the more chemically diverse proteins are typically in the range of 0.8 to 0.9.

Owing to the proportions of carbohydrate, fat and protein in a balanced diet having a reasonable level of consistency, it is possible to relate CO_2 production to total energy comsumption with an acceptable level of reliability – particularly where an animal is not subject to any nutritional stress and its basic nutritional requirements are being fully met (Pedersen *et al.*, 2008).

4.1.14 Units

Version 1 of LATSA (Marosszéky, 2009) generally relied upon United States (US) customary units, which have historically been the units commonly used in the aircraft-related industries. However, there appears to be a growing acceptance of metric units in the aircraft industries. Considering this, as well as the computational and interpretational benefits generally provided by metric units, in version 2 of LATSA, *Système International* (SI) units have been used for all data entry and in all calculations and reports.

4.2 Animal factor algorithms

4.2.1 Lower critical temperature

Freer *et al.* (2007) provide two interrelated equations for predicting lower critical temperature (LCT) in ruminants. These were used in version 2 of LATSA and are given by the following:

$$LCT = t_b + (E/A) \times I_e - [(H_m/A) \times (I_t + I_e)]$$

Equation 5

$$I_e = \frac{r}{rad + F} \times \frac{1}{0.481 + 0.326 \times v^{0.5}} + r \times \ln \frac{rad + F}{rad} \times \left(z - 0.017 \times v^{0.5}\right)$$

Equation 6

Where:	*LCT*	= lower critical temperature (°C);
	t_b	= core body temperature (°C);
	E	= evaporative loss (MJ/m².d)
	A	= surface area of animal body (m²);
		= 0.09 x $W^{0.66}$
	W	= liveweight (kg);
	H_m	= metabolic heat production (MJ/d);
		= k x W^n
	k	= an empirically derived coefficient;
	n	= an empirically derived exponent (typically a value of 0.72);
	I_t	= tissue insulation (°C.m².d/MJ);
	I_e	= external insulation (°C.m².d/MJ);
	rad	= radius of animal body (mm);
	F	= depth of coat or fleece (mm);
	z	= thermal insulation (°C.m².d/MJ/mm); and
	v	= air speed (km/h).

The above equations assume – not unreasonably – that even under calm conditions some air movement occurs, and therefore a minimum airspeed of 0.36 km/h (0.1 m/s) applies. Applying airspeeds lower than this limit may result in erroneous estimates from Equation 6.

Of those listed above, acclimatisation is the principal factor not incorporated into the above equations.

Table 2 provides a comparison of lower critical temperatures estimated using Equation 5 and Equation 6, with some values from other recognised sources, such as *Effect of Environment on Nutrient Requirements of Livestock* (NRC, 1981), and *Standards for the Microclimate inside Animal Transport Road Vehicles* (SCAHAW, 1999).

Table 2: Comparison of lower critical temperatures (°C) under calm dry conditions predicted using Equation 5 and Equation 6 (Freer *et al*, 2007), with values given in NRC (1981) and SCAHAW (1999)

Species	Class or condition	Freer *et al*	NRC	SCAHAW
Cattle*	newborn calf	14	9	10
	1 month old calf	2	0	0
	beef cow	-12	-21	5 to -40
	dairy cow, high milk yield	-37	-40	-24 to -30
Sheep	newborn lamb	22	—	10
	shorn ewe, 5 mm wool	18	18	15
	ewe, 50 mm wool	-7	9	-9 to -15

* European cattle or *Bos primigenius taurus*

Some of the minor disparity evident between the same species in Table 2 appears due to a lack of consistency between the sources in respect to the energy intake (*e.g*. fasting *vs*. maintenance *vs*. *ab libitum* feed supply), coat or fleece depth, growth rate, milk yield, age, weight, *etc*. within the same class of animal. In some cases, the applicable values for these parameters are not stated in the different sources, and consequently any standardisation is difficult.

4.2.2 Upper critical temperatures

Unfortunately upper critical temperatures do not lend themselves as easily as lower critical temperatures to their estimation using simple predictive equations. However, tabulated values are published in scientific literature. The tabulated UCT values used in version 2 of LATSA, and which have been taken from *Standards for the Microclimate inside Animal Transport Road Vehicles* (SCAHAW, 1999), are listed in Table 3[7].

Table 3: Upper critical temperatures (°C) for cattle, sheep and goats (SCAHAW, 1999)

Species	Class or condition	Typical	<80% RH	>80% RH
Cattle**	calf, 0 – 2 weeks	30	30	27
	calf, 50 kg LWT[8]	30	30	27
	>26 weeks	—	30	27
	beef cattle	28	—	—
	dairy cattle	25	—	—
Sheep	lamb, 0 – 2 weeks	30	—	—
	ewe, shorn	30	32	29
	ewe, full fleece	—	28	25
Goat	generic	30	30	27

** European cattle or *Bos primigenius taurus*

[7] While the two sets of tabulated UCT values in Table 3 are differentiated by an ambient relative humidity threshold of 80%, it would seem unlikely that this threshold would be exceeded under normal conditions in level flight (cruise conditions). However in case such conditions did occur, despite the very low probability of occurrence. These two sets of UCT values have been incorporated in the UCT tables in LATSA.
[8] LWT = liveweight or live body mass

4.2.3 Total heat production

Possibly reflecting a more widespread need to house grazing animals indoors during winter, much of the scientific literature pertaining directly to heat production in livestock (other than pigs or poultry) originates from North America and Europe. The *Design of Ventilation Systems for Poultry and Livestock Shelters* (ASAE, 1986) and *Climitization of Animal Houses* series (CIGR, 1992 & 2002) appear to be the more commonly cited documents in this regard.

ASAE (1986) provide tabulated values for total (and sensible) heat, compiled from a number of individual studies involving various classes, ages and liveweights of livestock species, housed at various ambient temperatures[9]. An example relating to male Ayrshire calves, and taken from Table 1 in ASAE (1986), is reproduced here in Table 4.

Table 4: Total heat production in male Ayrshire calves (source ASAE, 1986)

Liveweight (kg)	Age (days)	Temperature (°C)	ϕ_{tot} (W/kg)*
39	8	3	2.9
40	14	3	2.8
45	25	3	3.0
39	8	23	2.4
40	14	23	2.3
44	24	23	2.4

* W/kg = Watts per kg LWT. 1 Watt = 1 Joule/second (J/s)

As can be seen from Table 4, the general application of the tabulated ASAE (1986) data requires some degree of interpolation and extrapolation. Discrete tabulated values do not lend themselves to direct usage in the LATSA software, although it is possible to fit regression equations to the tabulated values to facilitate interpolation and extrapolation. However, the fitting of species-specific regression equations is constrained by it being unclear as to what extent the reported differences between the values for different genotypes in the ASAE data are due to the normal stochastic variability about mean values for that species, as opposed to statistically significant or 'true' differences between genotypes.

In contrast to the approach in ASAE (1986), the more recent CIGR (2002) publication provides a series of predictive equations for total heat. These equations relate to a relatively comprehensive range of livestock species, and are based on the likely basal metabolisable energy requirements of the animals[10]. The metabolisable energy requirements are modified by additional terms in the equations to account for factors such as current growth rate, milk production and stage of foetal development (if applicable). To some extent, the accounting for differences in growth rate or milk production may coincidentally account for some genotype differences – perhaps overcoming one of the issues with the tabulated ASAE (1986) data. Table

[9] As the data are compiled from numerous studies, these temperatures are not consistent between species or classes of species. Some of the listed temperatures are also likely to be outside of the thermoneutral range for the animals involved.

[10] Total energy production is related to a parameter termed the metabolic body weight, which is generally given by the function $MBW = k \times m^n$. Except for calves, the value of the exponent *n* listed in Table 5 for each species or class of animal is 0.75. While applicable values for the exponent are subject to debate in scientific literature, 0.75 is the value most accepted. However, CIGR (2002) provide 0.70 as the exponent value for calves, and values other than 0.75 for a few other animals (mainly juveniles). Applicable values for the variable *k* are derived empirically, and display some species specificity, although for mammalian species, values in CIGR (2002) are generally in the range of 5.5 to 6.5.

5 lists the equations for total heat production provided in CIGR (2002) for species of interest in this review.

Table 5: Predictive equations for total heat production in livestock (CIGR, 2002)

Species	Class or condition	ϕ_{tot} (W)	
Cattle	Calf	$\phi_{tot} = 6.44 \times LWT^{0.70} + \frac{13.3 \times y_2 \times (6.28 + 0.0188 \times LWT)}{1 - 0.3 \times y_2}$	**Equation 7**
	Lactating/pregnant cow	$\phi_{tot} = 5.6 \times LWT^{0.75} + 22 \times y_1 + 1.6 \times 10^{-5} \times p^3$	**Equation 8**
Sheep	Lamb	$\phi_{tot} = 6.4 \times LWT^{0.75} + 145 \times y_2$	**Equation 9**
	Lactating/pregnant ewe	$\phi_{tot} = 6.4 \times LWT^{0.75} + 33 \times y_1 + 2.4 \times 10^{-5} \times p^3$	**Equation 10**
Goat	Generic	$\phi_{tot} = 6.3 \times LWT^{0.75}$	**Equation 11**
	Lactating goat	$\phi_{tot} = 5.5 \times LWT^{0.75} + 13 \times y_1$	**Equation 12**

Where:
- *LWT* = individual animal liveweight (kg);
- y_1 = milk production (kg/day);
- y_2 = daily liveweight gain (kg/day); and
- *p* = stage of gestation (days post-mating).

Notionally, the above predictive equations for total heat production only pertain to thermoneutral conditions. CIGR (2002) provide considerable discussion as to whether certain generic and species-specific linear or curvilinear relationships provide the best fit when adjusting predictions for ambient temperatures that are outside of the thermoneutral range. Assuming that the aim of managing the environment in the aircraft hold is to maintain temperatures within the thermoneutral range, these relationships for temperatures outside the thermoneutral range are not discussed here.

Compared to other approaches, the potential advantages of the CIGR (2002) equations listed in Table 5 are as follows:

- *Their more recent development suggests that they should be based on a more extensive body of scientific literature;*
- *Being equations, they obviate the specific computational need to interpolate between or extrapolate from the discrete tabulated values in ASAE (1986); and*
- *The incorporation of terms for variables other than body weight into equations should allow easier incorporation of these factors into estimates of total heat production.*

Given the considerations above, version 2.0 of LATSA utilises each of the equations listed in Table 5 in turn to provide sensible heat loss for the various type of livestock. **It should be noted that version 2.0 of LATSA calculates total heat production on an individual animal basis then sums the results where required. The software calculates other physiological factors in a similar manner and can therefore deal with a widely varying consignment.**

4.2.4 Sensible heat loss

ASAE (1986) provide tabulated values for sensible heat loss corresponding to the tabulated total heat values discussed above.

GIGR (2002) provide the following generic relationship for estimating sensible heat loss from total heat production:

$$\phi_{sen} = 0.8 \times \phi_{tot} - 0.38 \times t^2$$

Equation 13

Where: ϕ_{sen} = sensible heat loss (W/hpu);
ϕ_{tot} = total heat production (W/hpu); and
t = ambient temperature (°C).

The unit W/hpu represents Watts/heat production unit. A 'heat production unit' is a standardised unit adopted by the Commission Internationale du Génie Rural (CIGR), and which represents a group of animals – of whatever makeup – that produces 1 000 W of total heat (ϕ_{tot}) at 20°C. To undertake the calculations on an individual animal basis (*i.e*. W/animal), it is necessary to revert to the comparable formula for sensible heat given in CIGR (1992), which is:

$$\phi_{sen} = \phi_{tot} \times \left[0.8 - 1.85 \times 10^{-7} \times (t + 10)^4\right]$$

Equation 14

Where: ϕ_{sen} = sensible heat loss (W/animal);
ϕ_{tot} = total heat production (W/animal); and
t = ambient temperature (°C).

Although not explicitly stated, the above relationships presumably represent curvilinear regression equations that have been fitted to data similar that in the left-hand graph in Figure 5 (page 20).

It might also be noted that near the midpoint in the thermoneutral range (*i.e*. ~20°C in most cases), sensible heat would effectively represent around two thirds of total heat output. Conversely, latent heat would represent about one third of total heat output at such temperatures.

Similar benefits and disadvantages in respect to the use of tabulated values and equations for total heat production apply to the above methods of estimating sensible heat loss.

4.2.5 Moisture loss in the form of water vapour

ASAE (1986) again provides discrete moisture loss rates (g H_2O/kg/hr) corresponding to most (but not all) of the tabulated total heat values described in Section 4.2.3 (above).

CIGR (2002) provide no specific means of estimating either latent heat or moisture loss. However, if values for both total and sensible heat are known, latent heat loss (ϕ_{lat}) can then be estimated from Equation 4 on the basis that:

$$\phi_{lat} = \phi_{tot} - \phi_{sen}$$

Equation 15

From first principles it then follows that moisture loss can be estimated from predicted latent heat loss, and the known latent heat (*i.e*. vaporisation enthalpy) of water. In version 2 of LATSA this estimation is achieved using the following equation:

$$\omega_{animal} = \frac{\phi_{lat}}{\lambda} \times 3600$$

Equation 16

Where:	ω_{animal}	= moisture loss (g/hr/animal);
	ϕ_{lat}	= latent heat loss (W/animal); and
	λ	= latent heat of vaporisation at temperature *t*°C (kJ/kg)
		= 2501 – 2.36 x *t* (kJ/kg)

It should be noted here that all reference to moisture loss by respiration is in the form of water vapour. That vapour will only condense to liquid if the pyschrometric conditions are favourable.

4.2.6 Carbon dioxide production

This relationship between CO_2 production and total heat can then be expressed by the following equation (CIGR, 2002):

$$C_{pr} = k \times \phi_{tot}$$

Equation 17

Where:	C_{pr}	= CO_2 production;
	k	= a respiratory quotient dependent coefficient; and
	ϕ_{tot}	= total heat production.

Various units can be applied to the above equation; although comparable units must be applied to the individual variables in any one computation.

CIGR (2002) indicated that for RQ values of 0.8 to 1.2, values for *k* of between 0.142 to 0.195 m³/hr/hpu [11] had typically been used up to that time, with a generic value of 0.163 m³/hr/hpu being commonly applied. However, evidence was by then accumulating which suggested these values represented modest underestimates. Pedersen *et al*. (2008) subsequently suggested that 0.185 m³/hr/hpu was a more suitable generic value for *k*, with the values in the range of 0.160 to 0.210 m³/hr/hpu being applicable where RQ values were known and in the range of 0.9 to 1.2.

[11] hpu = heat production unit = 1000 W of total heat produced by animals @ 20°C

4.2.7 Animal activity and behaviour effects

The preceding heat production or loss equations assume that the animal is in a resting state. Energy expenditure associated with increased animal activity is, however, going to affect the total heat produced. A need to compensate for aircraft movement[12] or behavioural responses to any stress associated with handling and transport can cause increased levels of physical or metabolic activity – albeit often only of a transient nature – with a commensurate increase in total heat production.

SAE AIR1600 (SAE Aerospace, 2003) recommends that the total heat production of animals during loading and handling may increase up to 4 to 5 times that produced during rest. In version 2 of LATSA the potential for an increase in total heat production due to the above has been accommodated by the incorporation of an 'behaviour factor', which is applied to estimates of total heat production (and thus in turn affects sensible and latent heat loss values). Given industry comment in regard to on-board animal handling practices and in-flight temperature feedback, a value of 10% has been used (*i.e*. actual ϕ_{tot} = 1.1 x resting ϕ_{tot}).

4.2.8 Manure and bedding moisture

Evaporation from voided animal faeces and urine – collectively termed 'manure' here – can make a significant contribution to atmospheric moisture levels in a confined environment (SCAHAW, 1999).

The evaporative flux rate will depend in part on the manure temperature and moisture content, as well as the ambient temperature, air speed and humidity or vapour pressure (Liberati & Zappavigna, 2005). The exposed surface area (evaporative interface) of the manure will also influence areal evaporation rates (*i.e*. when expressed as g $H_2O/m^2/hr$ or similar). As part of a large, integrated, animal housing model, Liberati & Zappavigna (2005) provide the following relationship for estimating evaporative losses from manure:

$$\omega_{manure} = S_d \times a_0 \times R \times \Delta pw$$

Equation 18

Where:	ω_{manure}	=	evaporation from manure (kg/s);
	S_d	=	manure surface area (m^2);
	a_0	=	evaporation coefficient (7.12 – 26.6 kg/m^2/hr/Pa);
	R	=	ventilation rate (m^3/s); and
	Δpw	=	vapour pressure differential (Pa) between the air and evaporative surface.

Equation 18 is used in version 2 of LATSA. S_d is equivalent to the total floor area of all tiers in a consignment. In practice, crates do not become fully saturated until sometime during a flight. In addition, no attenuation systems have been considered in the software although access to an reductionattenuation constant could be provided. As a result, the approach adopted in version 2 of LATSA may generate a higher value for ω_{manure} than occurs in practice, which in turn may result in a higher relative humidity result than in practice.

[12] Particularly during takeoff, landing and turbulence

4.3 Aircraft ventilation algorithms

4.3.1 Energy and mass balance

SAE AIR1600 (SAE Aerospace, 2003) recommends energy and mass balance approaches to estimating environmental variables in aircraft holds carrying livestock. Such approaches are based on the 'laws' of the conservation of mass and energy. These laws can be expressed as a standard mass or energy balance equation having the form:

$$\sum \text{outflows} = \sum \text{inflows} + \text{ change within the system}$$

Equation 19

While *SAE AIR1600* provides equations for calculating humidity and CO_2 levels in ventilated holds, it recommends heat balance calculations for estimating hold temperatures. One limitation of this approach is the difficulty of quantifying variables, such as heat loss or gain through the aircraft skin, using the scant information available in the public domain.

Under cruise conditions, *SAE AIR1600* treats ventilation air in pressurised aircraft as the dominant sink for sensible and latent heat, and aside from leakage, the sole means of removing CO_2. *SAE AIR1600* also assumes that conditions will approach a steady state under cruise conditions. Thus, it is not unreasonable to consider an aircraft analogous to any other form of livestock housing, and the approaches to energy and mass balance modelling used in designing such housing should be capable of being applied to the prediction of environmental conditions in aircraft holds accommodating livestock.

The ASAE Standard *EP270.5 Design of Ventilation Systems for Poultry and Livestock Shelters* (ASAE, 1986) provides generic energy and mass balance equations for use in estimating ventilation requirements in livestock housing. Expressed in terms of the associated change in air temperature and mixing ratio, these equations are shown below as Equation 20 and Equation 21 respectively.

$$T_n - T_0 = \frac{\phi_{sen}}{c_p \times F_v}$$

Equation 20

Where:

	T_n	= outflow temperature (°K or °C);
	T_0	= inflow temperature (°K or °C);
	ϕ_{sen}	= sensible heat exchanged[13] in ventilation air (W or J/s);
	c_p	= specific heat of moist air (J/kg/°K); and
	F_v	= ventilation rate (kg/s).

$$r_n - r_0 = \frac{\omega_{total}}{F_v}$$

Equation 21

Where:

	r_n	= outflow mixing ratio (water:air as g/kg);
	r_0	= inflow mixing ratio (water:air as g/kg);
	ω_{total}	= total water vapour generated by the load through respiration (ω_{cargo}) and evaporation (ω_{manure}) (g/s); and
	F_v	= ventilation rate (kg/s).

[13] The exchange can be either a net gain or loss of sensible heat

The approach adopted in Equation 21 can similarly be applied to the mass balance of CO_2 within each hold.

While Equation 20 and Equation 21 are not used directly in LATSA V2.0 they provide the basis of the mass balance approach which is utilised in Sections 4.3.2 to 4.3.4 and further in Section 4.4 to generate environmental system equations which LATSA V2.0 uses to provide specific results for temperature, relative humidity and CO_2 concentration.

4.3.2 Sensible heat loading

Assuming steady state conditions and parameterising the energy balance form of Equation 19, the sensible heat[14] balance within an aircraft hold can then be expressed as:

$$\phi_s = \phi_{s\,\text{cargo}} \pm \phi_{s\,\text{skin}} + \phi_{s\,0} - \phi_{s\,v}$$

Equation 22

Where:
- $\phi_{s\,v}$ = sensible heat in ventilation system outflow (W);
- $\phi_{s\,0}$ = sensible heat in ventilation system inflow (W);
- $\phi_{s\,\text{cargo}}$ = sensible heat generated by cargo (W); and
- $\phi_{s\,\text{skin}}$ = sensible heat gain (+) or loss (-) through the aircraft skin (W).

Rearranging Equation 20 (page 32), the sensible heat exchange associated with a temperature change can be expressed as:

$$\phi_s = c_p \times F_v \times (T_n - T_0)$$

Equation 23

If it is assumed that the amount of sensible heat transferred through the aircraft skin is not significant then when expressed in terms of more appropriate or readily quantified variables, Equation 22 becomes:

$$(T_n - T_{n-1}) \times \frac{V_h \times \rho}{\Delta\tau} \times c_p = \phi_{s\,\text{cargo}} + F_v \times c_p \times (T_0 - T_{n-1})$$

Equation 24

Where:
- T_n = hold air temperature (°K) at time *n*;
- T_{n-1} = hold air temperature (°K) at time *n*-1;
- V_h = hold headspace volume (m³);
- ρ = density of hold headspace air (kg/m³);
- c_p = specific heat of moist air (J/kg.°K);
- $\Delta\tau$ = nominal time increment (s); and
- T_0 = influent air temperature (°K).

To ignore skin losses is a relatively conservative assumption, since we are considering the maximum allowable sensible heat load under cruise conditions[15] when it is more likely sensible heat will be lost rather than gained through the aircraft skin.

[14] Heat is a form of energy that can be transferred from one body or thermodynamic system to another. Sensible heat can be sensed by humans. It is that portion of total heat associated with temperature change (*i.e*. total heat = sensible+ latent heat).

Rearranging the terms in the above equation, the hold temperature at time *n* can be determined as:

$$T_n = T_{n-1} + \frac{\left[\phi_{s_{cargo}} + F_v \times c_p \times (T_0 - T_{n-1})\right] \times \Delta\tau}{V_h \times \rho \times c_p}$$

Equation 25

Equation 25 is analogous to those commonly used in similar transient animal environment models – *e.g*. Panagakis & Axaopoulos (2004), Aerts & Berckmans (2004) and Sun & Hoff (2009).

As the sensible heat load generated by the cargo ($\phi_{s_{cargo}}$) at any one time is not constant, but dependent upon the antecedent hold temperature (T_{n-1}), both T_n and $\phi_{s_{cargo}}$ need to be calculated on an iterative basis. However, as the estimates here pertain to cruise conditions, where the hold environment should generally approach a steady state, for computational simplicity it is possible to curtail the calculations once T_n and T_{n-1} converge to within some nominal limit (*e.g*. the difference is less than say 0.01%). Owing to its interdependence on temperature, the value of $\phi_{s_{cargo}}$ in Equation 25 will likewise have stabilised at the point of convergence. If the variable τ then represents the length of the cruise phase of the flight (in units of $\Delta\tau$), the resulting iterative computational algorithm can be stated as:

For $n = 1 \rightarrow \tau$

$$T_n = T_{n-1} + \frac{\left[\phi_{s_{cargo}} + F_v \times c_p \times (T_0 - T_{n-1})\right] \times \Delta\tau}{V_h \times \rho \times c_p}$$

If $\left|\frac{(T_n - T_{n-1})}{T_n}\right| \leq 0.0001$, then End, else

Next n

Read T_n

Equation 26

Equation 26 is used in version 2.0 of LATSA to calculate the exit air temperature of the hold. It should be noted that this stable exit temperature is not the average temperature of the air in the hold and that the average temperature experienced within the hold may be somewhat lower due to the positioning and direction of cold inlet airflows. Modelling of airflow within the hold and around cargo was not part of the project scope.

[15] While heat loss through the aircraft skin may be considered negligible in the LATSA calculations, this conservative approach may mean the steady state result obtained may be higher than achieved in practice.

4.3.3 Latent heat and moisture load

Following a mass balance approach in lieu of the energy balance one used above to estimate the steady state hold temperature (refer Section 4.3.2), the steady state mixing ratio for water in the air in the aircraft hold can be predicted using the following iterative relationship:

$$\begin{aligned}
&\text{For } n = 1 \rightarrow \tau \\
&r_n = r_{n-1} + \frac{\left[\omega_{cargo} + F_v \times \left(r_0 - r_{n-1}\right)\right] \times \Delta\tau}{V_h \times \rho} \\
&\text{If } \left|\frac{\left(r_n - r_{n-1}\right)}{r_n}\right| < 0.0001, \text{ then End, else} \\
&\text{Next } n \\
&\text{Read } r_n
\end{aligned}$$

Equation 27

Where:

	r_n	= mixing ratio (g/kg) at time n;
	r_{n-1}	= mixing ratio (g/kg) at time n-1;
	ω_{cargo}	= water vapour load (g) emitted by cargo; and
	r_0	= mixing ratio (g/kg) of influent air.

Although Equation 27 is directly utilised in version 2.0 of LATSA, it remains an intermediary step to generating a more easily understood result for Relative Humidity (see Section 4.4.3)

4.3.4 Carbon dioxide concentration

As with sensible heat and water vapour, the carbon dioxide (CO_2) balance in the hold can be predicted using the following relationship:

$$\begin{aligned}
&\text{For } n = 1 \rightarrow \tau \\
&C_n = C_{n-1} + \frac{\left[CO_{2\ cargo} + F_v \times \left(C_0 - C_{n-1}\right)\right] \times \Delta\tau}{V_h} \\
&\text{If } \left|\frac{\left(C_n - C_{n-1}\right)}{C_n}\right| < 0.0001, \text{ then End, else} \\
&\text{Next } n \\
&\text{Read } C_n
\end{aligned}$$

Equation 28

Where:

	C_n	= CO_2 concentration (mg/m³) at time n;
	C_{n-1}	= CO_2 concentration (mg/m³) at time n-1;
	$CO_{2\ cargo}$	= CO_2 emitted by cargo (mg/s); and
	C_0	= CO_2 concentration (mg/m³) in influent air.

Equation 28 is used directly in version 2.0 of LATSA to provide a result for CO_2 concentration. The ratio of CO_2 in the inlet air is assumed to be the same as at sea level. Therefore the concentration may be estimated by considering air density (see Section 4.4.4)

4.4 Secondary psychrometric calculations for aircraft ventilation

4.4.1 Consignment "flags"

A group of parameters discussed in this section were considered as "flags" for allowable consignment conditions. These parameters included Effective Temperature (ET), Upper Critical Temperature (UCT) and Wet Bulb Temperature (WBT). The results of the various calculations for these parameters are included in the ESC results for each hold. However, the validity of using various parameters as black and white decision factors for what is considered short haul transportation is questionable. In particular, high ET values for flights of eight to ten hours do not present a significant issue unless those conditions were present before the flight and continue for a considerable time after the flight (i.e. days not hours). Of all the parameters, WBT was chosen as the primary (go / no-go) decision factor in Version 2 of LATSA primarily because of its acceptance in the HotStuff software used in assessment of sea freight of livestock shipments.

While parameters such as Temperature Humidity Index (THI) and UCT remain in the ECS results they are provided as guidance only and should not be considered as primary decision factors regarding consignments.

Many of the preceding computations rely on known or calculated values for various psychrometric or environmental variables. The standard equations used to calculate the specific heat of air, mixing ratio, and air density are detailed below as well as the most appropriate methodologies for other parameters found in the literature review process (see Section 3.2).

4.4.2 Specific heat of air

The specific heat of moist air (c_p) is given by:

$$c_p = c_{pd} \times \left(1 + 1.84 \times 10^{-3} \times r\right)$$

Equation 29

Where: c_{pd} = specific heat of dry air (J/kg/°K);
= 1004.67 J/kg/°K; and
r = mixing ratio of water vapour (g/kg).

4.4.3 Mixing (humidity) ratio

The mixing ratio of water vapour in the hold atmosphere can be determined (with reasonable accuracy) on the basis:

$$RH \approx \frac{r}{r_s} \times 100 \quad \text{or}$$

$$r \approx \frac{RH \times r_s}{100}$$

Equation 30

Where: RH = relative humidity (%); and
r_s = mixing ratio at saturation (g/kg).

$$r_s = \frac{0.622 \times e_s}{P - e_s}$$

Equation 31

Where: e_s = saturation vapour pressure (kPa).

$$e_s = 0.611 \times \exp\left[5423°K \times \left(\frac{1}{273°K} - \frac{1}{T}\right)\right]$$

Equation 32

Where: T = temperature (°K).

4.4.4 Air density

In level flight, the atmospheric pressure in the cabin and pressurised holds of a modern aircraft are less than at sea level. The density of air in an aircraft hold under cruise conditions can therefore be determined as:

$$\rho = \frac{P}{P_{sl}} \times \rho_{sl}$$

Equation 33

Where:
ρ = density of air in the aircraft hold (kg/m³);
P = atmospheric pressure in the aircraft hold (kPa);
P_{sl} = atmospheric pressure at sea level (kPa); and
ρ_{sl} = density of air at sea level (kg/m³).

The density of air at sea level is normally assumed to be 1.225 kg/m³, and the atmospheric pressure is similarly assumed to be 101.325 kPa. Typically the atmospheric pressure in an aircraft hold is held at around 85% of sea level pressure, although the precise operational atmospheric pressure in the aircraft cabin and holds varies with aircraft make and model, and can be further regulated, within certain parameters, by aircraft engineers and the flight crew.

4.4.5 Ventilation rates

In the many older industry publications, as well as IATA standards, the ventilation rates in aircraft are expressed in terms of the number of times the entire volume of air in the passenger cabin (or cargo hold) is being notionally replaced each hour (*n.b*. this assumes an empty cabin or hold, with a completely mixed, non-stratified atmosphere in that space). The ventilation rate units applied in these publications and standards are typically air changes per hour (ACH).

In version 2 of LATSA, the ventilation rates in the calculations rely on the use of SI volumetric (*e.g*. m³/hr) or mass (*e.g*. kg/s) units, rather than ACH units. Thus it was necessary to convert the published ACH values to SI volumetric units. This was done using the following equation.

$$F_v = \frac{V \times ACH}{3600}$$

Equation 34

Where:
F_v = ventilation rate (m³/s);
V_h = empty hold volume (m³); and
ACH = air changes per hour (ACH).

As well as ACH values, the IATA standards list the empty cargo hold volumes for Boeing aircraft. Unfortunately this volumetric flow data level is not available in the IATA standards for Airbus aircraft, and in most cases it was not possible to obtain SI unit values to verify those derived from version 1 of LATSA. Other sources of spatial hold data consulted in this process included MAC (1984), Mikolajczak & Moore (2001), Boeing (2003) and Airbus (2004).

To derive ventilation rates expressed in terms of unit mass, the SI unit volumetric rates were adjusted for the nominal operational air pressure in the cabin or hold under cruise conditions. While typically around 85 kPa, these values do vary slightly for different makes and models of aircraft, and so the representative values used in version 2 of LATSA were generally derived from manufacturer's specifications or the like (see Section 9.2 Appendix 2 – Aircraft Data Tables).

For calculations that require the velocity of air movement within the hold (*e.g*. the lower critical temperature for the consigned species), that velocity was estimated using the volumetric flow rate and the cross sectional area of the hold at the loading positions for ULDs. Cross-sectional areas for different makes and models of aircraft were obtained by digitising cross-sectional drawings of main and lower holds provided in manufacturer's airport planning publications (*e.g*. Boeing's 2002 *747-400 Airplane Characteristics for Airport Planning* or Airbus' 2009 *A380 Airplane Characteristics*). In the digitising process the US unit dimensions were converted to SI units, prior to the area of a polygon the same shape as the hold perimeter being calculated. **Error! Reference source not found.** provides an example of the process applied; in this case for the main hold in an Airbus A330-200F.

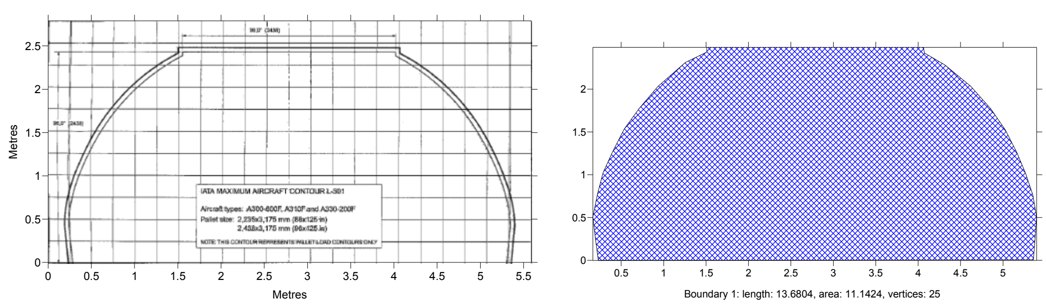

Figure 7: Cross-sectional area of a A330-200F main hold

In an aircraft cargo hold, the effective ventilation rate will be affected by the volume of air in the hold that is displaced by the cargo. Consequently it is the headspace air, or the free air volume in the hold that is actually being changed by the ventilation system. In version 2 of LATSA the headspace volume is therefore considered to be the difference between the empty hold volume, and the combined volume of the volumetrically-largest of the ULDs able to be held at each available loading position in the hold.

4.4.6 Wet bulb temperature

By themselves temperature and humidity do not provide a reliable indicator of thermal comfort or the relative risk of heat stress in animals. Concepts such as web bulb temperature and effective temperature[16] have been developed to provide a better indication of their combined effects in humans.

Since the latent heat used for evaporation comes from the sensible heat associated with the cooling, then:

$$c_p \times (T_d - T_w) = -L_v \times (r - r_w)$$

Equation 35

Where:	c_p	=	specific heat of moist air (J/kg.°K);
	T_d	=	dry bulb temperature (°C or °K);
	T_w	=	wet bulb temperature (°C or °K);
	L_v	=	latent heat of vaporisation (J/kg); and
	r_w	=	wet bulb mixing ratio (water:air as g/kg).

If the temperatures in **Error! Reference source not found.** have units of °C, the ambient mixing ratio is given by:

$$r = r_w - 4.0224 \times 10^{-4} \times (T_d - T_w)$$

Equation 36

The wet bulb mixing ratio is further given by:

$$r_w = \frac{0.622}{1.631 \times P \times \exp\left(\frac{-17.67 \times T_w}{T_w + 243.5}\right) - 1}$$

Equation 37

Where: P = atmospheric pressure (kPa).

While the above equations are useful for estimating the mixing ratio (humidity) from the wet bulb temperature, the converse is not true, and Normand's Rule or Theorem needs to be applied to provide an estimate of T_w when the mixing ratio is known. This method of estimating, using Normand's Rule, is computationally complex, involving the further estimation of the lifting condensation level (or more simply a parcel of air's saturation point as a result of cooling) and the dew point temperature. Consequently a number of authors have provided regression equations that allow estimation of T_w using simpler regression equations, as well as using more readily quantifiable variables. Martinez (1994) provides a polynomial regression equation that provides one such approximation of T_w. This method uses the following equations:

[16] The effective temperature is numerically equal to the temperature of still, saturated air which induces an identical sensation

$$T_w = \left[-\frac{Q}{2} + \left(\frac{Q^2}{4} + \frac{S^3}{27} \right)^{\left(\frac{1}{2}\right)} \right]^{\left(\frac{1}{3}\right)} + \left[-\frac{Q}{2} - \left(\frac{Q^2}{4} + \frac{S^3}{27} \right)^{\left(\frac{1}{2}\right)} \right]^{\left(\frac{1}{3}\right)} - 1$$

$$Q = 8264.65 - 1480.45 \times \left(\frac{RH}{100} \right) \times e_s - 0.966 \times \rho \times T_d$$

$$S = 662.23 + 0.97 \times \rho$$

Equation 38

Where: RH = relative humidity (%);
e_s = saturation vapour pressure (kPa); and
ρ = air density (kg/m³).

Error! Reference source not found. has been used in the calculation of WBT in version 2 of LATSA and its use as a primary decision factor ("Consignment Flag") is discussed in Section 4.9.

4.4.7 Effective temperature

To date the most utilitarian, non-specific approach available in livestock is provided by the Temperature Humidity Index (THI), which was originally developed by Thom in 1959.

$$THI = T_d + 0.36T_p + 41.2$$

Equation 39

Where: T_p = dewpoint temperature (°C);

THI values derived from the above equation serve as the basis for the Livestock Weather Safety Index (LWSI); (LCI, 1970) and have been used by the U.S National Weather Service for advisories (USDC-ESSA, 1970). Widely recognised thresholds for the LWSI (LCI 1970) are listed in Table 6 below. These thresholds have been principally applied to dairy and beef cattle held under intensive conditions in the US.

Table 6: THI category thresholds

Safety index	THI
Normal	≤74
Alert	75 to 78
Danger	79 to 83
Emergency	≥ 84

While these thresholds have been considered appropriate over a number of years, there has been considerable ongoing analysis and development (Mader et al, 2006). As an example "*THI-hrs analysis of the 1995 heat wave and others have reinforced the LWSI thresholds for categories of risk, and support an environmental profile for single heat wave events that create conditions likely to result in deaths of Bos-taurus cattle in feedlots: 15 or more THI-hrs per day for three or more successive days at or above a base level of 84 (Emergency category of the LWSI) with minimal or no night time recovery opportunity. Death losses can be expected if shade,* *precautionary wetting, or other relief measures are not provided during such conditions.*" (Hahn et al, 2006).

It is therefore important to note that the emergency level recommended in LWSI can be exceeded for lengthy periods during the "day" if respite is available at "night". In the case of livestock transportation by air, both the limited length of the flight and in-flight environmental control systems may provide sufficient respite to overcome significant "short term" heat stress.

Heat tolerance will also vary between species and the values in Table 6 should be considered against the period of exposure. It may be more effective to consider the accumulated heat load over time as exposure to higher THI may occur for relatively short periods of time without any noticeable impact. The impact of high exposure could be more noticeable during loading, take-off and landing were ESC systems are generally curtailed.

A modified form of Equation 39 generates similar index values based on dry bulb temperature (T_d) and relative humidity (RH)[17] are provided by the following equation (Hahn *et al*., 2009):

$$THI = 0.8 \times T_d + RH \times (T_d - 14.4) + 46.4$$

Equation 40

This latter method, Equation 40, is used in version 2.0 of LATSA to provide an estimate of the effective temperature however the calculations rely only on the temperature of the hold and its relative humidity.

In addition to an expansion to the notion of accumulated heat load, it has been previously stated that the exit temperatures and moisture loads calculated using the above methods may over state the actual conditions in the hold which may place doubt on any firm reliance on THI as an environmental indicator. It should also be noted that the use of THI was developed for the external impact of weather systems and not for enclosed, controlled environments.

[17] Identical THI values can be obtained using dry bulb temperature in combination with either dew-point and wet bulb temperatures (both alternative measures of humidity) in analogous equations

4.5 Validation of animal factor algorithms

During May 2010, the methodology and algorithms being proposed for the estimation of critical temperatures and the total, sensible and latent heat in version 2 of LATSA were reviewed by third-party expert reviewers nominated by EnviroAg Australia, MLA and LiveCorp. Adjustments or modifications were then made to reflect any recommendations made by these reviewers.

Comparisons were also made at this time between the values obtained using these algorithms and those sourced from tabulated or graphical data in publications such as:

- *Design of Ventilation Systems for Poultry and Livestock Shelters (ASAE, 1986);*
- *Effect of Environment on Nutrient Requirements of Livestock (NRC, 1981);*
- *Live Animal Regulations (IATA, 2009a);*
- *SAE AIR1600 (SAE Aerospace, 2003); and*
- *Standards for the Microclimate inside Animal Transport Road Vehicles (SCAHAW, 1999).*

4.5.1 Sensible heat loss

The following graphs provide comparative plots of the estimates of sensible heat loss obtained using the equations in CIGR (2002), as previously presented in Section 0 (page 29), and those of the Society of Automotive Engineers (SAE, 2003), as provided in the documentation for the existing version of the LATSA software (refer Figure 6 in Marosszéky, 2009). The plotted values cover ambient temperatures ranging from ≤5°C to ≥35°C, which would be broadly analogous to the thermoneutral zone in most cases.

Figure 8 depicts estimates, from the CIGR (2002) and SAE (2003), of the sensible heat generated by a 45 kg and a 135 kg calf[18]. Liveweight gain in these animals was 0.5 and 1.0 kg/d respectively for the values derived from the CIGR (2002) equations. No liveweight gains were specified in respect to the SAE (2003) data, but growth rates of a similar magnitude might be expected to apply.

[18] At ambient temperatures above ~35°C, the sensible heat generated by the animals in Figure 8 decreases to less than zero. While this extrapolation of the plot line is an artefact of the curve fitting software used in this example, at these temperatures the animals are indeed likely to be gaining heat from external environment (*i.e*. the animal would not be generating or shedding sensible heat)

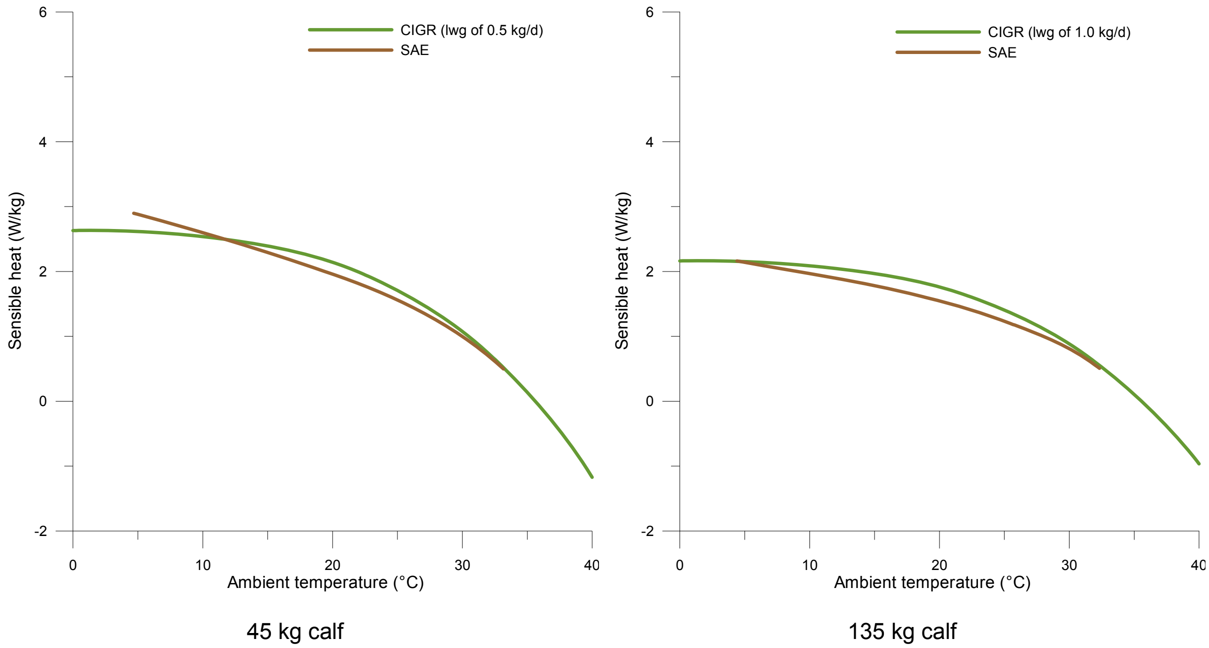

Figure 8: Sensible heat transfers a 45 kg and 135 kg calf

Both plots in Figure 8 show a good level of agreement; although growth rates other than those shown here in respect to the CIGR (2002) estimates would provide more disparate plots.

Figure 9 likewise provides estimates of sensible heat generated by mature cattle and sheep taken from the same two sources. For the estimates derived using the CIGR (2002) equations, the following conditions were assumed to apply:

- The 'dry' or non-lactating cow had a liveweight of 400 kg, was pregnant and was close to calving;
- The lactating cow similarly had a liveweight of 400 kg, was not yet pregnant and was yielding 35 kg or milk per day; and
- The sheep had a liveweight of 40 kg, and either a non-pregnant and not lactating ewe or whether, but with an unspecified coat (wool) length.

The SAE (2003) estimates in Figure 9 for 'cattle' are for animals of no particular type, liveweight or condition. Similarly the estimates for sheep do not identify a liveweight or stage of gestation or lactation, but do provide estimates for shorn and unshorn sheep – although the associated coat lengths are not specified.

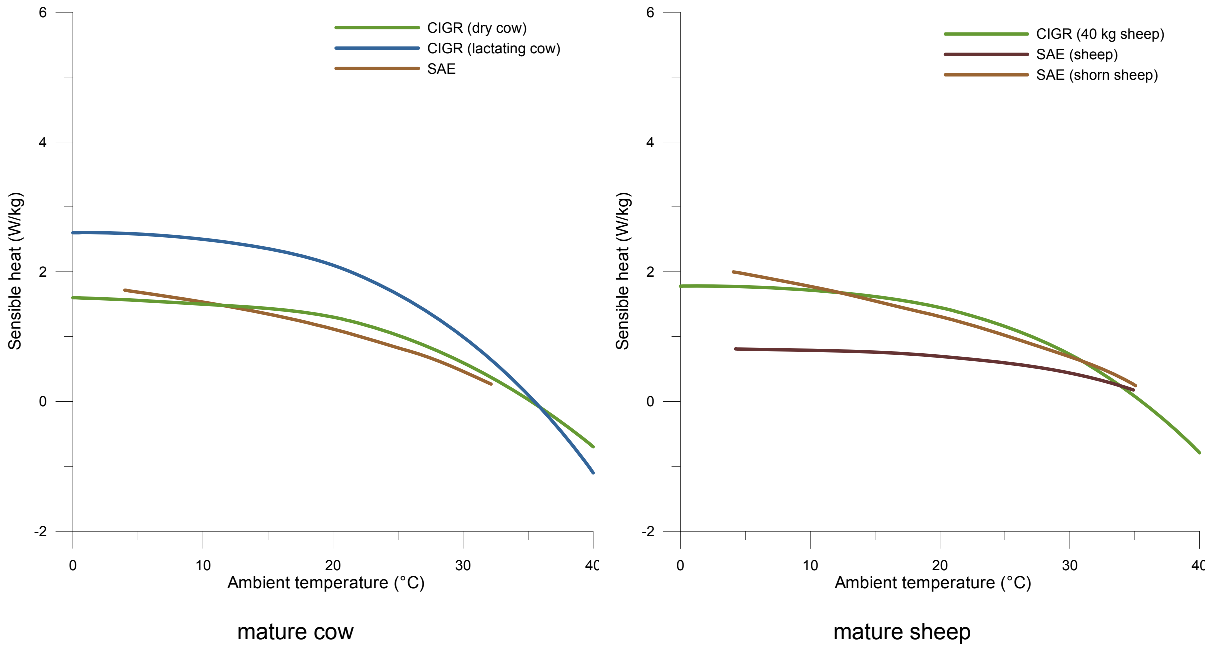

Figure 9: Sensible heat transfers by mature cattle and sheep

In Figure 9 there again is good general agreement between the SAE (2003) and CIGR (2002) values for 'cattle' and a dry cow respectively. However, some disparity is evident between the CIGR derived values for a high-yielding lactating cow, and the generic cattle values in SAE (2003). Nevertheless, a difference of this nature is not an unreasonable expectation in regard to a high producing animal. It is also an important one if animals in peak production are to be transported.

In respect to sheep, the plotline for a 40 kg sheep obtained using the CIGR (2002) equations coincided well with the SAE (2003) values for a shorn sheep, but less well in respect to an unshorn one.

Mindful that the SAE derived values plotted in Figure 8 and Figure 9 are not specific to any particular liveweight, production level or the like, there generally appears to be reasonable agreement between the two publications in respect to sensible heat loss.

4.5.2 Latent heat loss

Similar to the comparisons of sensible heat loss in Section 4.5.1, here Figure 10 and Figure 11 provide comparisons of the latent heat loss values obtained using the approach described in Section 4.2.5 (above)[19], with those provided in SAE (2003) for similar livestock. The SAE (2002) values correspond to those in the documentation for the existing version of the LATSA software (Marosszéky, 2009). The assumptions regarding the different animals that were listed in respect to the CIGR (2002) equations in Section 4.2.3 also apply here.

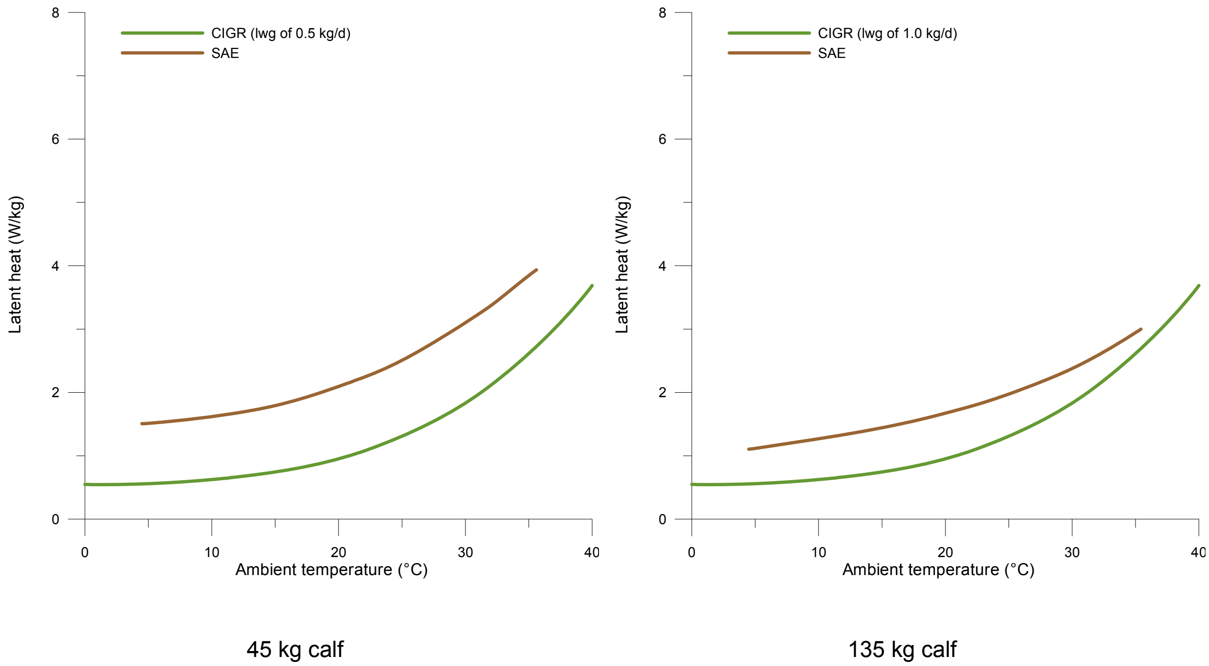

Figure 10: Latent heat loss by a 45 kg and 135 kg calf

Unlike in Figure 8 (page 43), the differences between the two sets of estimates plotted in Figure 10 are more marked – particularly in respect to the 45 kg calf. Further, since total heat production is the sum of latent and sensible heat, similar discrepancies might be expected in total heat estimates. However, owing to limited descriptions available for the animals in the SAE (2003) datasets, it is not possible to make an emphatic decision as to which of the two estimates is the more accurate. It may be observed though, that at around 20°C the latent heat loss estimates in the SAE (2003) data represent close to 50% of total heat production, whereas those obtained using the CIGR (2002) equations are closer to 30% of total heat production, and thus more in accordance with expectations.

[19] Derived from CIGR (2002)

Figure 11 provides comparisons of the latent heat loss estimates obtained from the two sources in respect to mature cattle and sheep.

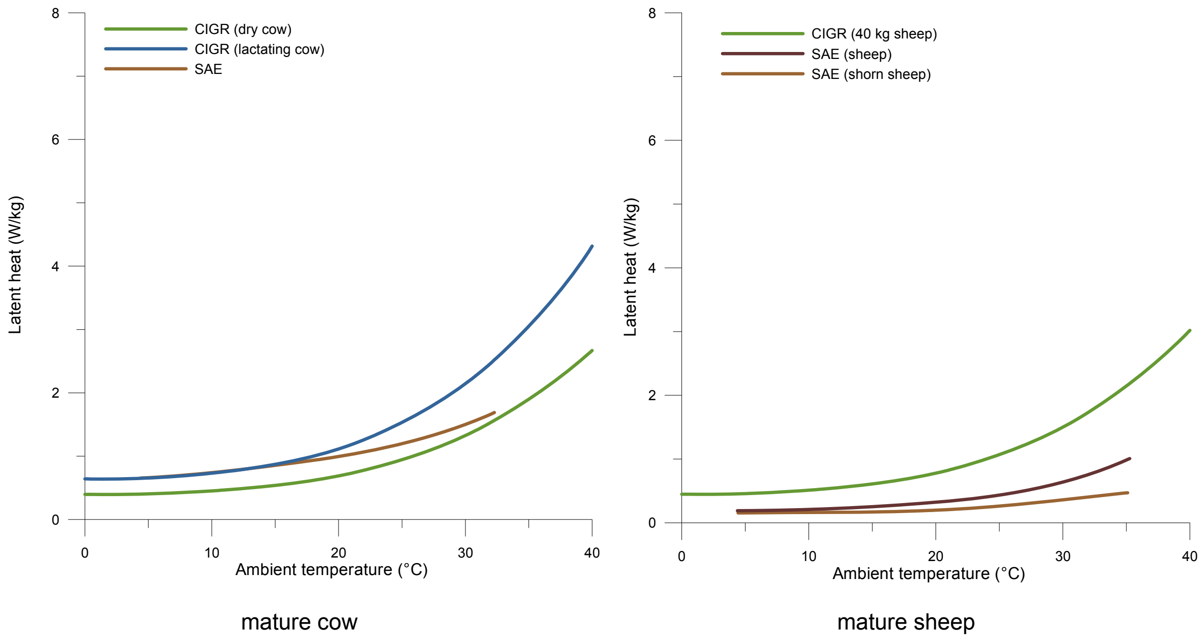

Figure 11: Latent heat loss by mature cattle and sheep

The estimates of latent heat loss for the mature cows show reasonable agreement, although the CIGR derived estimates for the lactating cow are closer to that for ‘cattle’ in the SAE (2003) data – the converse of the case in regard to sensible heat plotted in Figure 9. The two sources also differ significantly in respect to latent heat loss is sheep, but in this instance the CIGR-derived values are higher than the SAE (2003) values for both shorn and unshorn sheep. Again, based on the available information regarding the different animals, there is no compelling argument for supporting one or the other of these estimates being the more accurate or reliable.

4.5.3 Carbon dioxide production

In respect to CO_2 emission data from livestock and other animals, the current LATSA software documentation (Marosszéky, 2009) references Boeing Aircraft Corporation documents D6U10192, D6U10192-1 and D6-33380. Sheep and cattle are the only species of interest in this review for which values are presented in the chart provided in the LATSA documentation. Figure 12 provides a plot of these values, redrawn from the original chart after conversion to SI units (*i.e*. m³/hr/kg in lieu of the original ft³/hr/lb). Also plotted in Figure 12 are alternative estimates of CO_2 production by sheep and cattle in the same liveweight ranges, but in this instance based on the estimation methodology described in Section 4.2.6 (above).

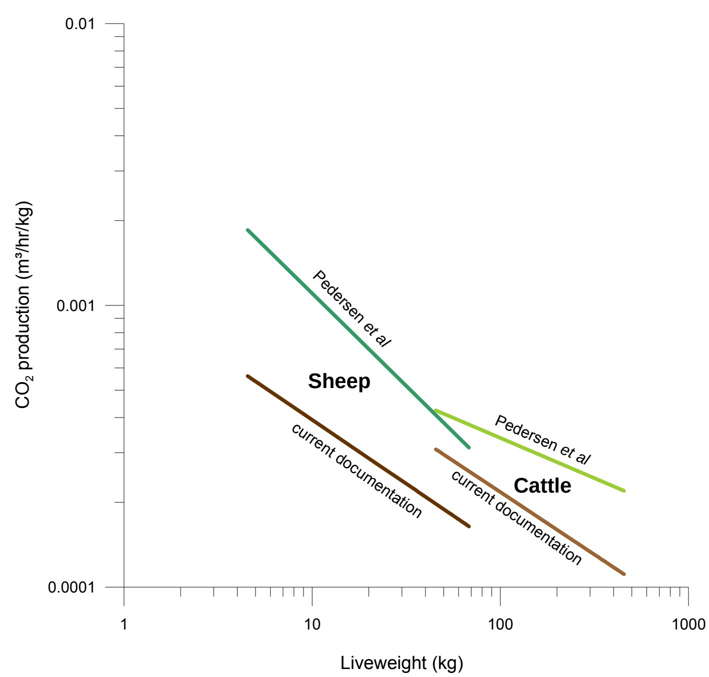

Figure 12: Comparison of CO_2 production in sheep and cattle referred to in the existing LATSA software and values based on estimated production values in Pedersen *et al.* (2008)

The alternative CO_2 production rates for sheep and cattle plotted in Figure 12 are both consistently higher than the values reference in the current LATSA software documentation (Marosszéky, 2009). It is unclear whether these differences reflect (1) fundamental differences in the approach to estimation and the algorithms applied; (2) the influence of recently revised values for component variables in estimation algorithms (*e.g*. *k* in Equation 17, or its equivalent in alternative predictive equations); or (3) continually improving levels of productivity in modern livestock (and hence comparatively higher levels of energy intake and thus CO_2 production).

4.6 Validation of aircraft ventilation algorithms

As previously indicated in Section 4.3.1, the approach adopted in predicting environmental conditions in an aircraft hold in this version of LATSA was to treat the hold as being analogous to any other form of enclosed animal housing, and utilise the methodologies and algorithms commonly adopted in modelling those environments. This approach is not inconsistent with recommendations for transient, computer-based modelling provided in Section 4 of *SAE AIR1600*. Nonetheless, to validate the resultant predictions it was considered desirable to obtain comparative values using a different methodology.

SAE AIR1600 provides an equation for estimating CO_2 concentrations in the holds of aircraft carrying livestock. The units applicable to CO_2 concentrations in that equation are percentage volume (%v/v). Accounting for the influent concentration of CO_2 and converting the concentration into units of parts per million volume (ppmv), in lieu of %v/v used in the original equation, the modified equation can be expressed as:

$$C_\tau = C_0 + \frac{\mathrm{CO}_{2\,\mathrm{cargo}}}{F_v} \times \left[1 - \exp\left(\frac{-F_v \times \tau}{V_h}\right)\right] \times 10^6$$

Equation 41

Where:
- C_τ = CO_2 concentration (ppmv) at time τ;
- C_0 = CO_2 concentration (mg/m³) in influent air;
- $CO_{2\,cargo}$ = CO_2 emitted by cargo (mg/hr); and
- F_v = ventilation rate (kg/hr);
- τ = time (hr); and
- V_h = hold volume (m³).

By applying the same principles, it is possible to modify Equation 41 to calculate effects on temperature and humidity of sensible heat and water vapour loadings. The resultant equations are as follows:

$$T_\tau = T_0 + \frac{\phi_{\mathrm{sen}} \times 3600}{F_v} \times \left[1 - \exp\left(\frac{-F_v \times \tau}{V_h}\right)\right] \Big/ \left(c_p \times \rho\right)$$

Equation 42

Where: T_τ = outflow temperature (°K or °C) at time τ.

And:

$$r_\tau = r_0 + \frac{\omega_{\mathrm{total}}}{F_v} \times \left[1 - \exp\left(\frac{-F_v \times \tau}{V_h}\right)\right]$$

Equation 43

Where: r_τ = outflow mixing ratio (water:air as g/kg) at time τ.

By applying the above equations to a diverse range of scenarios, it was possible to validate the algorithms in version 2 of LATSA. In all cases the validation calculations gave very similar results to the algorithms in this new version of LATSA, and which have been previously detailed in Section 4.3 of this report.

In respect to the secondary psychrometric calculations provided in Section 4.4, these equations were validated by comparing predicted values to those derived from the relevant psychrometric charts in *ASHRAE 872-RP: Psychrometrics – Theory and Practice* (ASHRAE, 1996), and sample calculations provided in Stull (2000).

4.6.1 Aircraft operational constraints

In utilising version 2.0 of LATSA, the Participant (Exporter) assumes that the nominated aircraft can operate at its full design ECS capacity. Where the Participant becomes aware that the aircraft has temporary ESC limitations and checks that box in the document section of the program, progress is halted until that issue has been discussed and managed with the carrier.

Version 2.0 of LASTA also assumes that each aircraft is operating to its respective maximum or minimum design specification. As an example, the inlet air temperature for a Boeing 747-400 is specified as 2^0C and that inlet temperature is used by the program as the inlet temperature constant for that aircraft.

Selection of the correct aircraft is therefore an important factor when utilising version 2.0 of LATSA.

4.7 Software Development

The validation process incorporated the development of a Microsoft Excel© spreadsheet which calculated results for single species configurations. This spreadsheet utilised the equations and methodology developed throughout the research phase of the project and results from the spreadsheet were utilised in the validation phase.

The database tables extracted from LATSA V1.0, the spreadsheet, completed reports, an equation list and the calculation methodology were used in the development of the SQL database and web based interface.

The structure and specification of the software has been discussed in Section 3.3. The incorporation of numerous issues in regard to aircraft, operators, holds, crates and animals generated significant complication due to the number of possible combinations. The table structure includes multiple linkages and many of the resulting selections are not unrestricted. While some fields e.g. Embarkation Ports and Operator's Aircraft have been specifically restricted, the provision of additional selection limitations was seen as both detrimental to acceptance of the system and more difficult to administer in the initial stages of release.

The development process involved several iterations of presentation, test, challenge and modification prior to its initial release to MLA and LiveCorp representatives. At least two more iterations occurred before presenting the program to potential users to test. Users were encouraged to enter actual data in order to identify any missing selections and inappropriate outcomes.

The methodology relating to animal physiology remained consistent throughout the software development phase. However some modifications were made to the methodology relating to aircraft ventilation as the software development proceeded in order to model results equivalent to actual outcomes.

- It was assumed that recirculation systems effectively mix air within a hold;
- Recirculated air was excluded from air mixing calculations. Only ventilation (exit air flow) was incorporated;

- The volume ratio for non livestock cargo remains defined and constant;
- The inlet air temperature was defined as the lowest design temperature for the aircraft;
- The inlet air humidity was set to 10% RH;
- The effect of animal disturbance in-flight was limited to a 10% increase in physiological outputs;

Much of the early effort in software development was concentrated on scientific and engineering outcomes. While this was necessary to ensure calculated outcomes accurately reflected the actual physical response, it became apparent that presentation rather than calculation methodology was the most critical factor for industry acceptance. Several of the latter iterations of test and modification resulted in relatively minor changes to data presentation.

Information relating to the operation of the system have been separated into Administration and User Manuals. Compete versions of these manuals can be found in Section 9.8 Appendix 8 – LATSA V2.0 Administrators Manual and Section 9.9 Appendix 9 – LATSA V2.0 Users Manual

4.8 Use of equations within version 2.0 of LATSA

A flow chart of the link between the software and the associated equations can be found in Section 9.3 Appendix 3 – Equation Flow Chart. This flow chart provides a summary of where equations listed in the report are used within the software. However, there are a number of other "engineering" calculations within the software which are not included as nominated equations within this report. Several examples are; the flight duration, the total net weight and gross weight of the loadlines and cargo, the required number of pallets, the actual stock density and space used. These have been ignored for brevity within the report but are fully documented within the source code.

4.9 Environmental Control System Results in version 2.0 of LATSA

In the preceding sections of this report there are a number of discussions regarding temperature, humidity and carbon dioxide calculations. As a result version 2.0 of LATSA has the capacity to compare numerous factors in developing an "ECS Result" which include:

- Lower Critical Temperature (LCT);
- Upper Critical Temperature (UCT);
- Relative Humidity (RH%);
- Wet Bulb Temperature (WBT);
- Temperature Humidity Index (THI); and,
- CO_2 Concentration

While LCT is calculated in version 2.0 of LATSA, there are very few occasions where it will have a bearing on the outcome of the results. This is because there is very limited air transportation of very young livestock where the inlet air temperature is similar to or below their corresponding LCT.

The tabulated values of UCT presented in Table 3 are included in version 2.0 of LATSA and can be compared to the calculated hold exit temperature. There may well be some situations where the hold exit temperature exceeds the UCT and an environmental constraint exists. UCT is still only a guide as to the conditions faced by livestock. It should be noted that UCT is only the point at which animals start to become affected (discussed previously). They can withstand lengthy periods above their UCT without any serious impact provided there is some respite.

THI is calculated via Equation 40 and is presented in version 2.0 of LATSA. As previously discussed, it may be more appropriate to utilise THI within an Accumulate Heat Load framework. As a result THI values are used as an indicator and not an environmental constraint within Version 2.0 of LATSA.

4.9.1 Wet Bulb Temperature

WBT is calculated and presented as an output in LATSA version 2.0. It is generated from dry bulb temperature and humidity via **Error! Reference source not found.**. The LATSA 2.0 software uses WBT heat stress thresholds as described in 'LIVE.116 Development of a heat stress risk assessment model' (MLA, 2003) as the primary indices for assessment of heat stress risk.

UCT was originally conceived as the primary decision factor. Minimum UCT values remain as a result but no longer form a constraint on the consignment. The primary heat stress parameter is now the minimum WBT at which mortalities could commence for various species of livestock. These values are used as the primary constraint (decision factor) against the calculated WBT and are detailed in Table 7.

Table 7: Maximum Wet Bulb Temperatures for Various Species (LIV.116, 2003)

Species	Wet Bulb Temperature
Bos Taurus - Beef	30.5^{0}C
Bos Taurus – Dairy	30.0^{0}C
Bos Indicus - 25%	32.5^{0}C
Bos Indicus - 50%	33.5^{0}C
Sheep - Lamb	33.3^{0}C
Sheep - Adult	33.7^{0}C
Goats(conservative)*	30.5^{0}C

* There is very limited WB data available for goats and a very conservative value (consistent with Bos Taurus – Beef) has been is used in version 2.0 of LATSA. This selection is based on comparable UCT values and the recommendations found in SAE Air 1600). Some adjustment may be necessary as a result of comparison with validated (empirical) results.

If the predicted WBT exceeds heat stress threshold limits found in Table 7, the LATSA software will present the following warning message in red "Exit temperature exceeds WBT for some animals".

It should be noted that these constraints are most valid for livestock being transported by sea. Exposure to the wet bulb temperatures listed in Table 7 is likely to be more extensive during sea-freight than by air due to the limited flight duration. Cases of excessive wet bulb temperature are less likely to eventuate than cases of excess relative humidity.

4.9.2 Other Constraints

Version 2.0 of LATSA assumes that mixing of air is effective within each hold and that the exit temperature is potentially the maximum within the hold. Most certainly there will be colder areas within the hold closest to air inlets. Conversely some areas within stock crates may have limited air movement and the localised temperature may be higher than that calculated in version 2.0 of LATSA. Modelling of airflow in the hold and within crates themselves did not form part of the scope of this project however some suggestion for ongoing investigation can be found in Section 5.2.

Water vapour respired from the livestock cargo and evaporated from manure will have a significant effect on the relative humidity. This will in turn, directly affect the THI value calculated within the program. As a result, a high THI value may result primarily from high humidity rather than high temperature. In this instance, higher air flow rates and better dispersal within the hold are necessary to alleviate discomfort. Many carriers take this into consideration by nominating crate positions with respective height limitations to improve air circulation. For these reasons and as discussed previously, WBT and associated heat stress thresholds have been used as primary constraints and THI remains in the software output as a reference.

While temperatures calculated within the hold refer to exit values, the calculation of relative humidity and carbon dioxide assume that thorough mixing has occurred in the free void space of the hold. The volume of the stock crates is considered solid. Therefore any physical movement of air through the crates will effectively reduce the values of RH% and CO_2 resulting from version 2.0 of LATSA.

Without empirical validation of the model it is difficult to determine the exact nature of the constraints to be applied within the program. As a result the following values have been nominated as constraint conditions:

- The fully mixed RH% must be less than 99% at the calculated dry bulb temperature exit temperature; and,
- The fully mixed CO_2 concentration must be less than 5000ppm.

The relative humidity constraint used in version 2.0 of LASTA is of concern as there are anecdotal comments about excessive humidity on various flights. In addition, some comment on the benefit of moisture entraining devices or materials used in air transport was received during the course of the project. Where elevated levels of humidity are encountered there is every probability of condensate forming on the cooler skin of the aircraft interior. Therefore, excessive moisture may have significant operational consequences for aircraft owners and could in some instances, be the cause of significant maintenance. It is therefore recommended that this be a primary subject of investigation in any following project.

A Participant utilising the software should take account of all the factors above together with the length of the flight when loads appear to exceed the nominated constraints. Implications should be discussed with the carrier or operator.

4.10 Industry Consultation

The beta version of the program was made available for industry use in November 2010. Several industry participants were invited to participate in a face to face training program and to advise on users' issues.

In late November and early December 2010, a series of user sessions were undertaken in several locations in Queensland and New South Wales. The results of these sessions were recorded and provided to MLA in a separate communication (see Section 9.4 Appendix 4 - Industry Consultation Outcomes). Outcomes of these sessions were separated into "Within Scope" and "Outside Scope" and agreed upon through consultation with MLA and LiveAir representatives.

Effective solutions to "Within Scope" issues were discussed with the software developers then implemented. As a consequence of several modifications, some of the "Outside Scope" issues were also resolved to the benefit of the project.

The solutions to "Within Scope" issues were detailed in a separate correspondence to MLA. The full response can found in Section 9.5 Appendix 5 - Completion of within scope changes.

The required modifications incorporated one correction to linked data within the ASEL calculations while the remainder related to changes to either administrator managed constants or the presentation methodology.

Two important factors to users of the system related to:

- A simplification of the technical response of the system
- A method of progression through the Consignment entry process

It was determined that industry acceptance would only be achieved when the technical requirements of data entry and modification of the software system were limited to only those within the control of the livestock exporter. For instance, the ability to alter on-board system parameters such as inlet temperature and airflow rates was removed.

Documentation relating to each consignment was reconstructed from that presented in LATSA V1.0 and the various existing industry documentation. Due to the data storage capacity of the system, documentation in LATSA V2.0 has been reduced to two primary outputs.

- *Aircraft Ground Handling Checklist – which consists of all current data requirements for AQIS including operator and aircraft approval, hold usage (all holds), transhipment details, species, numbers and crate details. In addition the document now provides crate manufacturer registration and certification details, actual and ASEL density results based on liveweight calculations and predicted ventilation outcomes.*
- *Exporters Report – which contains much of the information above in addition to flight details, total weights and the values of aircraft hold environment results for all hold in use.*

While the documentation is considered complete at this point there is an expectation that further modification may be necessary following a system presentation to AQIS later in 2011.

Further comment was accepted from the developer of version 1 of LATSA and can be found in Section 9.6 Appendix 6 – Additional Industry Comment. The response to these comments can be found in Section 9.7 Appendix 7 – Response to Additional Industry Comment

5 Success in achieving objectives

5.1 Overall success

Table 8 provides a summary of the project objectives listed in Section 2. Also shown are an assessment of the success in meeting those objectives and a reference to either (1) sections of this report describing how that outcome was achieved; or (2) reference to the software where it can be demonstrated that the required attribute has been successfully incorporated into version 2 of LATSA.

Table 8: Summary of objectives met at the completion of the project

Nominated objective	Result	Reference
• *Review version 1 of LATSA*	successful	section 3.3
• *Validate and amend parameters for cattle, sheep and goats*	successful	sections 4.2 & 4.5
• *Extrapolate to include all animal liveweights*	successful	section 4.2
• *Calculate ASEL stocking densities*	successful	section 4.1.4
• *Calculate total area and payload*	successful	software attribute
• *Incorporate an approved crate designs database*	successful	section 3.4.2
• *Be able to nominate use of a specific type of crate*	successful	software attribute
• *Allow mixed consignments*	successful	software attribute
• *Determine adequacy of ventilation*	successful*	sections 4.3, 4.4 & 4.6
• *Have capacity to recalculate if ventilation inadequate*	successful	software attribute
• *Design software for secure access on the World Wide Web*	successful	section 3.3

* *n.b.* as previously indicated (refer Section 1), the indicative adequacy of the aircraft ventilation only relates to level flight (cruise conditions)

5.2 Potential improvements in future versions

5.2.1 Monitoring data for verification of LATSA predictions

While an attempt has been made in this project to validate the computational methods and algorithms employed in version 2 of LATSA, more confidence could be had in the predictions if monitoring data were available to allow verification[20] of those predictions. These data are not currently available, particularly for shipments of cattle, sheep, goats and camelids being shipped out of Australia. It is therefore strongly recommended that data-loggers being placed in some shipments to gather a suitable body of data for verification purposes, prior to further development of the LATSA software.

Whilst the LATSA predictions are in most cases conservative, this empirical validation process would be designed to determine if and why actual values exceed the predicted values. This process may also discover additional operational parameters which need to at least be

[20] In this context *validation* is taken to mean confirmation that the approach used is a scientifically sound one, whereas *verification* is taken to mean confirming that predicted values are consistent with actual data

addressed in communications between the exporter and carrier (that have not already been identified).

5.2.2 Spatial and temporal variability in hold conditions

A very small body of monitoring data on hold conditions during livestock shipments is available in published literature. These publications, however, suggest significant spatial and temporal variability in hold conditions can be encountered during these flights.

Xin and Rieger (1995) provide monitoring data in respect to barometric pressure, temperature and relative humidity during one journey between the northern USA and China. Figure 13 is a redrawn graph depicting that monitoring data. The data were recorded at five minute intervals inside naturally ventilated, palletised, 50 litre fibreboard cartons, routinely used for the air-transport the chicks (88 chicks per carton). The span of the data in Figure 13 is from the time of the dispatch of the day-old chicks from the hatchery in the USA, to their receipt at a poultry farm in China, and includes some road travel in addition a multi-leg air journey. The actual in-flight time, which is less than 50% of the duration of the total journey in Figure 13, can be identified by the periods of lower barometric pressure (*i.e*. <90 kPa). The remainder of the time was either spent in road travel (the initial and final stages), or on the ground, prior to, between, or following the three airborne stages in the journey.

It can be seen from Figure 13 that the in-flight periods were not only characterised by lower barometric pressure, but also lower temperatures and lower humidity than those generally experienced during the periods on the ground. It is also noted that:

- *Neither temperature nor relative humidity were constant during the airborne legs of the journey (i.e. entirely uniform in-flight conditions did not occur); and*
- *Elevated relative humidity levels and temperatures (possibly representing stressful conditions for the subject chicks) were experienced on the ground during the aircraft-related legs of the journey.*

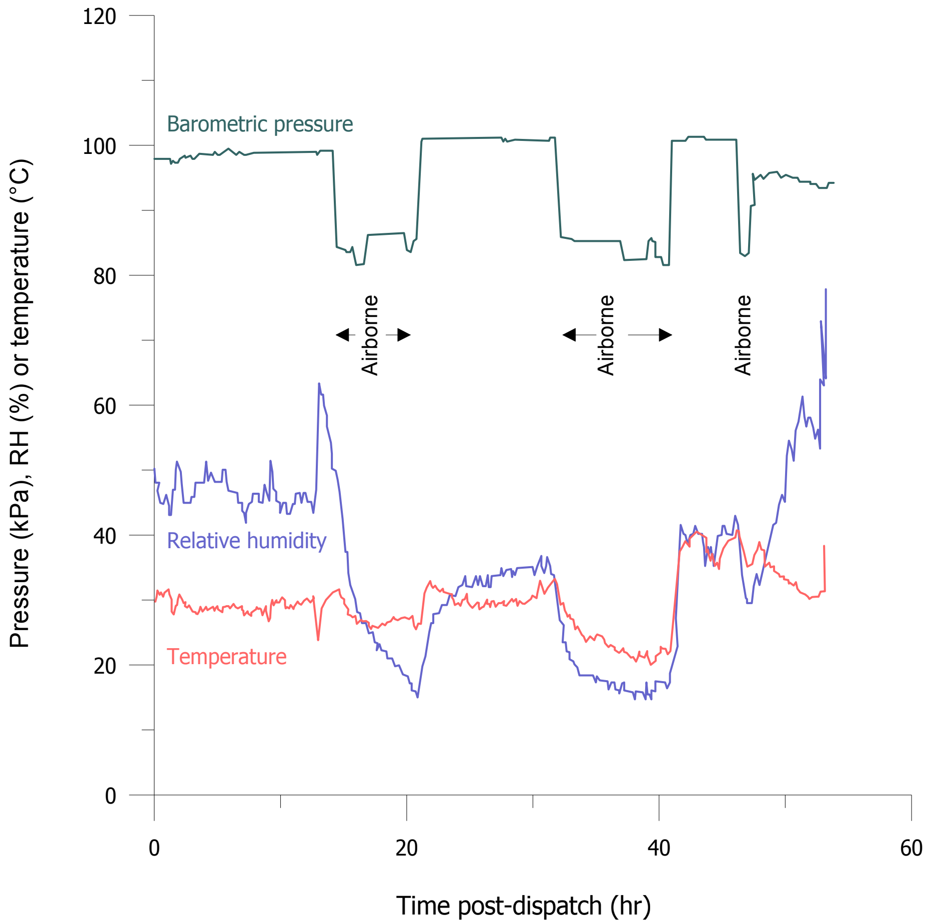

Figure 13: Example of changes in barometric pressure, temperature and relative humidity during the transport of day-old chicks from the USA to China (redrawn from Xin & Rieger, 1995)

In the above example, once the aircraft become airborne recovery from elevated on-ground temperature and humidity levels was progressive, rather than immediate. Even on the longer, second airborne stage of the journey in Figure 13, neither temperature nor humidity stabilised completely during the approximately ten hour flight. This is at some variance with conditions as might be predicted by version 2 of LATSA, which suggests that conditions stabilise relatively quickly once in level flight (cruise mode).

Syversen *et al.* (2008) obtained not dissimilar results to Xin and Rieger (1995) when they monitored the temperature during 103 shipments of laboratory mice on domestic (USA) and international flights. The mice were sent using 5 different couriers, in the holds of both passenger and dedicated freight aircraft. Temperatures were logged at 1-minute intervals using sensors placed on the outside[21] of plastic, proprietary shipping containers. An individual container held up to 20 mice, together with an absorbent corncob-based bedding material, feed, and a water-based gel as a drinking water supply. They found that 49.5% of consignments were exposed to elevated temperatures (>29.4°C) still within the thermoneutral zone for mice, 14.6% to low temperatures (<7.2°C), and 61% to temperature variations of 11°C or more. Higher

[21] Trials were undertaken to establish that there was rapid equilibration in temperature between the sensor, taped to the outside of the shipping container, and the temperature inside the plastic container that housed the mice.

temperature excursions were more common on international flights (77% of international flight *vs*. 40% of domestic flights). A courier who used passenger planes had the highest number of temperature excursions – possibly, they suggested, due to passenger aircraft movements being more common in the daytime, and freight aircraft movements being more common at night. The highest temperature recorded in the study was 65.6°C, during a daytime stopover. The mice in that particular shipment all died.

Again of note from the results provided by Syversen *et al.* (2008) were that:

- *Conditions experienced in-flight were often markedly different to those during stopovers; and*
- *During hot weather it took some time for the temperature to stabilise, if it did at all, after takeoff (i.e. it followed a classical exponential 'drawdown' or decay curve).*

In a study of horses being transported from Australia in a proprietary equine crate (an Airstable®), Thornton (2000) observed that temperatures inside the crate were relatively stable during each flight (18.7 – 23.4°C), but were significantly warmer than in the cargo hold itself (13.9 – 18.3°C). Relative humidity fluctuated more than temperature, and was strongly influenced by the external conditions during on-ground stages in the journey.

Other anecdotal and experiential information would suggest that the results presented above may not be entirely unrepresentative of the general conditions experienced on livestock-carrying flights out of Australia. It might also suggest that:

- *Temperatures recorded in the aircraft hold may not be entirely representative of those in a livestock crate; and*
- *On-ground hold conditions at intermediate or refuelling stops are possibly more important than in-flight conditions in respect to the risk of heat stress.*

Based on the above it is recommended that any monitoring of hold conditions not only look at conditions in the hold headspace or outside of the crates, but:

- Seek to assess variability within the hold – particularly with different permutations and combinations of ULDs in the holds;
- Compare conditions within crates with headspace conditions; and
- Assess the effectiveness of flight-deck managed changes to the HVAC system.

5.2.3 Boeing live animal cargo environment manuals

It is understood that Boeing publishes what are termed '*live animal cargo environment*' manuals for all contemporary models of Boeing aircraft. However, these documents are not readily available outside of the company or its customers. Hence obtaining a comprehensive set of manuals, able to cover all Boeing aircraft types likely to be used for shipping livestock out of Australia, has proven problematic – leastwise within the timeframe of this project. Nonetheless, a copy of *Live Animal Cargo Environment in Model 747-400 Freighters* (Boeing, 1994) has been sighted in the course of undertaking this project and it has been determined that use of this material would be useful.

The manuals provide a somewhat different approach to the matters addressed by LATSA. They use a series of graphs to estimate the 'allowable' sensible heat, water vapour and CO_2 loadings in each hold on a Boeing aircraft. The graphs, which are in part based on *SAE AIR1600* or its predecessors, allow for a comparison of the consignment's sensible heat, water vapour and CO_2

emissions, and the capacity of an aircraft's heating, ventilating and air conditioning (HVAC) system to handle those emissions. These graphs also take into account variables such as aircraft skin temperature and the aircrew-selectable operational settings of the HVAC system – variables that it has not been possible to consider (or required to be considered) in this version of LATSA.

By applying the relevant values drawn from these graphs it is possible to derive a relatively simple yes/no assessment of the acceptability of the proposed consignment (*i.e*. the load is either within allowable limits or not). Importantly, using this data or information can negate the need to quantify parameters such as empty hold volume or ventilation rate, which have proven difficult to establish with complete certainty in this project. This approach also means that determining the operational capacity of the HVAC system rests almost entirely with the aircraft manufacturer. Furthermore, the graphs in these manuals cover not only cruise conditions, but also conditions during ascent and descent, and while on the ground – a desirable expansion of the current capabilities of LATSA.

An initial analysis of the 747-400 Freighter manual has shown that it is possible to render some of these graphs into relatively simple algorithms that could be incorporated into LATSA. The resulting comparison of loads and HVAC capacities provides what should be a very reliable means of determining the acceptability of nominated loads. Hence it is recommended that the parameterisation of the graphs in these manuals be pursued in future versions of LATSA. However, to do so will require obtaining a complete set of manuals, or comparable data, for all the makes and models of aircraft likely to be used for carrying livestock on flights out of Australia, including Airbus aircraft[22].

[22] It is understood Airbus Industries can supply owners of Airbus aircraft with proprietary software that may fulfil a similar function to that of the Boeing manuals, but access to this software appears restricted strictly to aircraft owners. It is unclear what are the capabilities of this software (compared to LATSA), or how many aircraft owners own or utilise copies of this software.

6 Impact on livestock industry

The primary impact of Version 2 of LATSA could be defined as follows:

- *To increase the level of confidence that exporters, regulatory authorities (e.g. the Australian Quarantine Inspection Service), aircraft operators and the general public can have in regard to the welfare of livestock being transported in aircraft.*

The project was developed from a need to satisfy regulatory authorities that the industry has the required knowledge and experience to manage air transport of livestock in a safe and effective manner. In effect the industry has been asked to confirm that any intended aircraft has sufficient ventilation capacity to transport a nominate load of livestock without sickness or fatality.

An earlier project incorporating the design and certification of livestock crates for air transport has been incorporated within the data structure of LATSA V2.0. This has been incorporated by identifying each and every crate manufactured for this purpose by Crate Manufacturer and Design. For the purpose of LATSA V2.0 this has been accomplished through the addition of Registration and Certification numbers against Crate Manufacturers and Livestock Crates respectively.

The software system has the capability to store and report all of the above factors relating to each and every consignment. Interested users may also be able to validate the inputs and results of others through their own secure system access.

On the basis that the methodology behind the system has been validated scientifically and through comparison with several sources of research and empirical results we believe that the software is a very important step in achieving the required level of confidence.

It is important to note that there is a significant body of engineering data held by aircraft manufacturers which is controlled intellectual property that relates to the transport of livestock. Much of this data can effectively validate the results achieved in LATSA V2.0. However there are several constraints in the availability and use of this information in comparison with LATSA V2.0:

- *It is controlled information and is only available for restricted use on request by aircraft owners;*
- *The information is generally in written form as graphical representations;*
- *The use of this data requires knowledge of aircraft systems in addition to other influencing variables such as air temperature and relative humidity at elevation;*
- *The information may have security implications;*
- *The information is proprietary and provides significant information upon which the ECS and other systems have been design.*

Through the process of aircraft research and the development of the software we have made one important discovery which appears contrary to the current accepted view of regulatory authorities:

- *If systems are correctly set by flight crews and airflows are not restricted by other cargo then the capacity of ventilation systems in lower holds of aircraft are generally better than main holds.*

This statement is based on the results of LATSA V2.0 for lower holds. We have found several sources of information relating to ECS settings for the transport of livestock. Each source suggests that HIGH air flow must be selected. LATSA V2.0 has been set accordingly and the results indicate the stable temperature of lower holds is more beneficial than what can be achieved in the main hold.

This occurs primarily as a result of the ratio of gross airflow to the volume of the hold (and subsequently to the number of livestock that can be accommodated in the hold). In all cases there is more air per animal than can be achieved on the main deck provided the restrictions nominated above are enforced.

Once an Exporter has consigned livestock to an aircraft operator there is no control over the system settings or load configuration. The expectation is that the aircraft operator is sufficiently experienced to:

- *Validate that their aircraft has the required ECS system capability;*
- *Determine the load configuration so it does not restrict or impede airflow;*
- *Ensure that flight crew are aware of the load requirements and make the required ECS settings.*

This discovery may have a significant financial impact on the industry but may require validation through the use of other methods such as on-board data monitoring.

We believe that in addition to the above, LATSA V2.0 simplifies the determination of consignment configuration and the provision of detailed consignment information to both the Exporter and regulatory body. In particular LATSA V2.0:

- *Allows the interpolation of ASEL densities for all liveweights of all nominated species;*
- *Indicates the number of livestock and or the number of crates required to fill and aircraft;*
- *Provides a useful tool for educating industry participants as to the factors impacting on the conditions on an aircraft that is transporting livestock.*

The ability of industry participants to improve conditions and methods is often dependent on knowledge and sometimes retrospective analysis. We expect that this upgrade of LATSA significantly improves the “black box” nature of the information systems available to exporters, allowing exporters to predict outcomes, validate them in practice and analyse situations which appear contrary to expectations.

While this project has primary responsibility to the air transportation of livestock it can have far more reaching affects. Confidence in air transport systems will of course increase the potential of this method of transport particularly for genetic stock destined for reproductive purposes. However, the action of instigating improved management systems in general, impinges on the whole live export system. The implementation of this software can only add to the level of general confidence in livestock transport industry.

The implementation of LATSA 2.0 may also improve the aviation industry’s general understanding of livestock transport. It will certainly assist those with limited understanding and potentially provide more a more cost competitive environment for exporters.

7 Conclusions and recommendations

7.1 Conclusions

The project has met the objectives detailed in Section 2. In doing so it has provided the industry with a reasonably flexible and accurate model which can be used to predict key outcomes on-board flights transporting livestock.

While the predicted animal physiology outputs can be readily validated through research and empirical data, aircraft ventilation is more complex. The ECS outcomes generated by version 2.0 of LATSA appear to be generally elevated in comparison to those observed by most but not all exporters. This is an intended consequence with the expectation that users would discuss anomalies with aircraft operators during the construction of proposed consignments to ensure that aircraft have the nominated ventilation capacity.

The software encompasses most if not all of the variables associated with livestock transport by air. These variables include ports, operators, aircraft, holds, manufacturers, crates, animals and liveweights. As a result the potential combinations are extensive and in an effort not to exclude choices in the initial acceptance stage of the implementation process, there are a number of non effective selections still available in the consignment building process. As a result some selections may create errors during early use of the software.

Response from early adopters has been encouraging with the expectation that exporters will find the software tools relatively easy to use and suitable for their own needs. In addition, the software provides much more information than was previously available to justify a higher level of confidence within and outside of the livestock air transport industry segment. This higher level of confidence is based on publicly available aircraft ESC data. While the results provide much more information than was previously known, caution must be taken in relying on the results of version 2.0 of LATSA due to the way in which it uses maximum and minimum design specifications within its calculations.

7.2 Recommendations from project

It has previously been noted that the predictions provided in Version 2 of LATSA relate only to conditions in level flight. Expansion of the capabilities of the software to include conditions during takeoff and landing, as well as while the aircraft is on the ground, is highly recommended. It would be beneficial to have capability to graphically represent variation in the main ECS factors over time.

It is evident that the aircraft ventilation calculations could be improved by the incorporation of allowable sensible and latent heat load calculations based on those in the Boeing '*live animal cargo environment*' manuals. More detail on these recommendations has been provided previously, in Section 5.2 of this report. While there is no evidence of similar flight manuals for AirBus aircraft this information should extend across all makes and models of aircraft.

Validation of model predictions is required to finesse various factors within the software such as moisture evaporation from manure, air inlet temperature, hold temperature distribution and animal output fluctuation. The variation of relative humidity, requires investigation as it appears to be one of the primary constraints to transportation of livestock by air.

In addition it is recommended that conditions within crates are compared by design, animal, stock density, hold location, head space and any other factors which might affect air distribution.

It would be beneficial that any data collected also incorporate variability in the HVAC system as a result of flight-deck managed changes. As a result the effectiveness of such changes could be properly accessed.

Our primary recommendation at this point is to gain industry acceptance of the tool as early as possible. This may require support from MLA, LiveCorp and industry bodies such as ALEC and LiveAir. The tool has the capacity to resolve many of the obstacles currently facing exporters in their desire to increase this mode of transportation. It will however, require ongoing maintenance to ensure that all users' selections are catered for within the data tables.

The primary advantage of the system is that it reduces the "black box" nature of aircraft ventilation and provides a relatively transparent mechanism which can provide an effective self regulating system.

Full acceptance may not occur until the regulating body (AQIS), have been properly introduced to the system and have had an opportunity to review the level of detail which is held within its structure.

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9 Appendices

9.1 Appendix 1 - List of symbols

Σ	Summation
λ	latent heat of vaporisation at temperature t°C (kJ/kg) = 2501 – 2.36 x t (kJ/kg)
τ	journey length (s or hr)
$\Delta\tau$	journey increment (s)
ω_{animal}	moisture loss (g/hr/animal)
ϕ_{lat}	latent heat loss (W/animal)
ω_{manure}	evaporation from manure (kg/s)
ϕ_{sen}	sensible heat loss (W/animal)
ϕ_{tot}	total heat production (W/animal)
ω_{total}	total water vapour generated by load (g/s)
a_0	evaporation coefficient (kg/m²/hr/Pa)
ACH	air changes per hour (ACH)
C_0	CO_2 concentration (mg/m³) in influent air
C_n	CO_2 concentration (mg/m³) at time n
C_{n-1}	CO_2 concentration (mg/m³) at time n-1
$CO_{2\ cargo}$	CO_2 emitted by cargo (mg/s)
c_p	specific heat of moist air (J/kg/°K)
c_{pd}	specific heat of dry air (J/kg/°K)
C_{pr}	CO_2 production
d	stocking density (m²/head)
E	evaporative loss (MJ/m².d)
e_s	saturation vapour pressure (kPa)
F	depth of coat or fleece (mm)
F_v	ventilation rate (kg/s)
H_m	metabolic heat production (MJ/d) = $k \times W^n$
I_e	external insulation (°C.m².d/MJ)
I_t	tissue insulation (°C.m².d/MJ)
k	a coefficient
LCT	lower critical temperature (°C)
L_v	latent heat of vaporisation (J/kg)
LWT	liveweight (kg)
n	an empirically derived exponent ≈ 0.72
P	atmospheric pressure in the aircraft hold (kPa)
p	stage of gestation (days post-mating)
P_{sl}	atmospheric pressure at sea level (kPa)
Q_v	ventilation rate (m³/s)
r	mixing ratio (water:air as g/kg)
R	ventilation rate (m³/s)
r_0	inflow mixing ratio (water:air as g/kg)
rad	radius of animal body (mm)
RH	relative humidity (%)
r_n	outflow mixing ratio (water:air as g/kg) at time n
r_{n-1}	mixing ratio (water:air as g/kg) at time n-1
r_s	mixing ratio at saturation (water:air as g/kg).

r_τ	outflow mixing ratio (water:air as g/kg) at time τ
r_w	wet bulb mixing ratio (water:air as g/kg)
S_d	manure surface area (m²)
THI	temperature humidity index
t	ambient temperature (°C)
t_b	core body temperature (°C)
t_{db}	ambient (dry bulb) temperature (°C)
T	temperature (°K)
T_d	dry bulb temperature (°K)
T_0	inflow temperature (°K)
T_n	outflow temperature (°K or °C) at time n
T_{n-1}	outflow temperature (°K or °C) at time n-1
T_w	wet bulb temperature (°C or °K)
UCT	upper critical temperature (°C)
v	air speed (km/h)
V	empty hold volume (m³)
V_h	hold headspace volume (m³)
y_1	milk production (kg/day)
y_2	daily liveweight gain (kg/day)
Z	thermal insulation (°C.m².d/MJ)
P	density of hold headspace air (kg/m³)
ρ_{sl}	density of air at sea level (kg/m³)
Δpw	vapour pressure differential (Pa) between the air and evaporative surface

9.2 Appendix 2 – Aircraft Data Tables used in version 2 of LATSA

Aircraft Tables currently loaded into version 2.0 of LATSA

Operator	Model	Variant	Min Temp ^0C	Max Temp ^0C	Available olds	Volume m^3	Compliant	Ventilation Rate m^3/hr
Air Canada	A330-200F		5	25	Main	1*	False	6750
			5	25	Forward	85	True	1691
			5	25	Aft	71	True	1043
Air Canada	A330-300P		5	25	Forward	107	True	1691
			5	25	Aft	86	True	1259
Atlas Air	B747-200F		2	31	Main	736	True	12591
			2	31	Forward	102	True	2039
			2	31	Aft	114	True	991
Atlas Air	B747-400BCF	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Atlas Air	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Cargolux	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Cathay Pacific	A330-200F		5	25	Main	1*	False	6750
			5	25	Forward	107	True	1691
			5	25	Aft	71	True	1043
Cathay Pacific	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
China Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
China Eastern	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Emirates	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Eva Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
FedEx	B727-200F		5	25	Main	114	True	2141
			5	25	Forward	20	False	
			5	25	Aft	22	False	
FedEx	B757-200F		2	31	Main	269	False	4055
FedEx	MD11F		4	21	Main	504	True	6797
			4	21	Forward	82	False	
			4	21	Aft	63	False	
Heavylift	B727-200F		5	25	Main	114	True	2141
			5	25	Forward	20	False	
			5	25	Aft	22	False	
Japan Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
KLM	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
KLM	MD11F		4	21	Main	504	True	6797

			4	21	Forward	82	False	
			4	21	Aft	63	False	
Korean Airlines	B747-400C	3 Pack	2	31	Main	326	False	5740
			2	31	Forward	102	True	3191
			2	31	Aft	114	True	991
Korean Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Malaysian Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
MartinAir	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
PolarAir	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Qantas	A330-300P		5	25	Forward	107	True	1691
			5	25	Aft	86	True	1259
Qantas	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Qantas	B747-400P		2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Singapore Airlines	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Southern Airlines	B747-200F	3 Pack	2	31	Main	736	True	12591
			2	31	Forward	102	True	2039
			2	31	Aft	114	True	991
Template	A330-200F		5	25	Main	1*	False	6750
			5	25	Forward	85	True	1691
			5	25	Aft	71	True	1043
Template	A330-200M		5	25	Main	1*	False	6750
			5	25	Forward	85	True	1691
		Modified	5	25	Aft	71*	True	1043
Template	A330-200P		5	25	Main	1*	False	
			5	25	Forward	85	True	1691
			5	25	Aft	71	True	1043
Template	A330-300P		5	25	Main	1*	False	
			5	25	Forward	107	True	1691
			5	25	Aft	86	True	1259
Template	A340-200FM	Modified	5	25	Main	1*	False	
			5	25	Forward	91*	False	1691*
			5	25	Aft	71*	False	1259*
Template	A340-200M	Modified	5	25	Main	1*	False	
			5	25	Forward	91*	False	1691*
			5	25	Aft	71*	True	1259*
Template	A340-200P		5	25	Main	1*	False	
			5	25	Forward	91*	False	1691*
			5	25	Aft	71*	False	1259*
Template	A340-300P		5	25	Main	1*	False	
			5	25	Forward	107	False	1691*
			5	25	Aft	86*	False	1259*
Template	A340-600P		5	25	Main	1*	False	
			5	25	Forward	107*	False	1691*
			5	25	Aft	86*	False	1259*
Template	A380P							
Template	B727-200F		5	25	Main	114	True	2141
			5	25	Forward	20	False*	

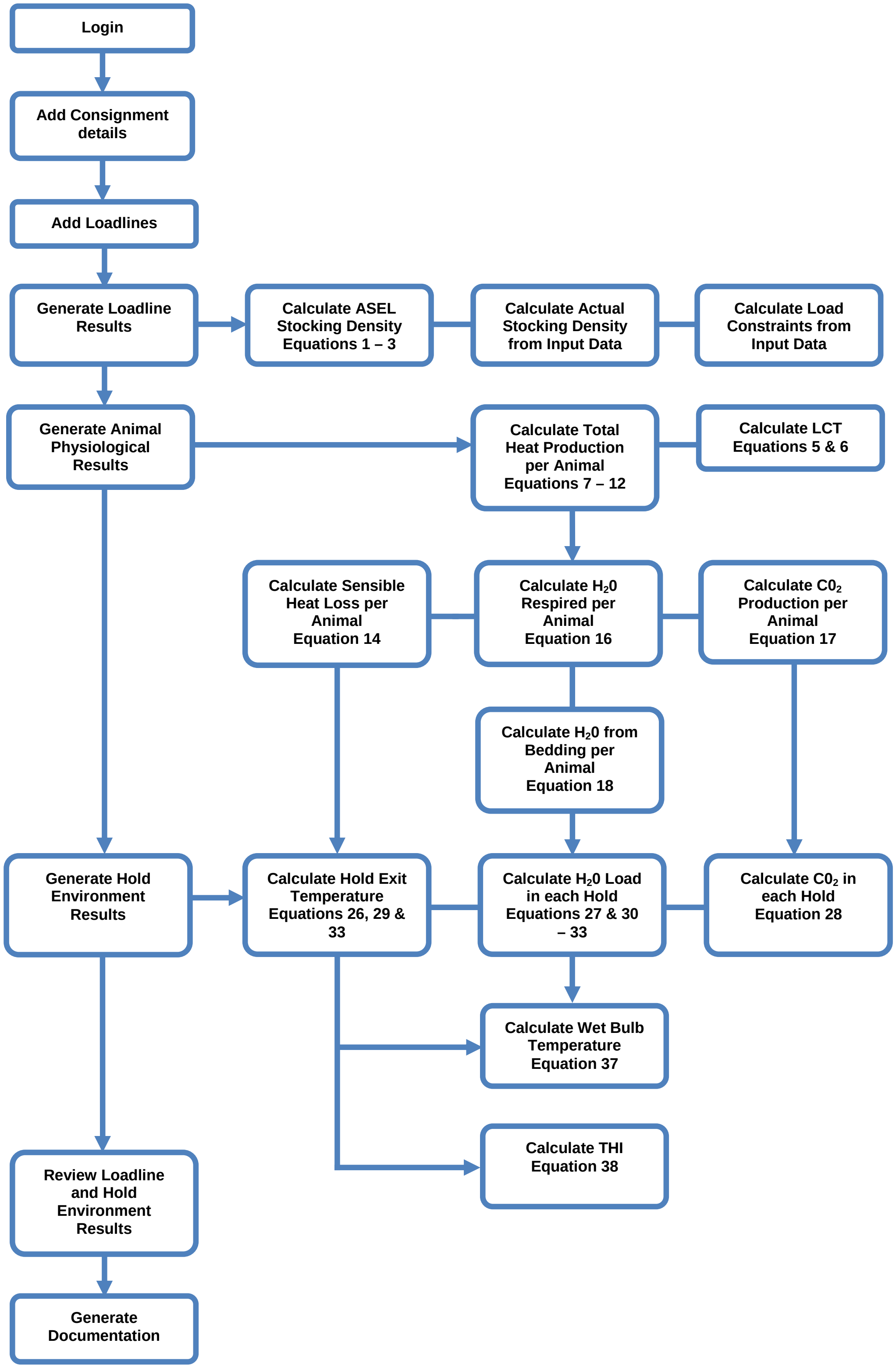
			5	25	Aft	22	False*	
Template	B737-300F							
Template	B747-100C		2	31	Main	830*	False	
			2	31	Forward	102	False	
			2	31	Aft	88	True	991
Template	B747-100P		2	31	Main	830	False	
			2	31	Forward	102	False	
			2	31	Aft	88	True	991
Template	B747-200C		2	31	Main	326	False	3387
			2	31	Forward	102	True	2039
			2	31	Aft	114	True	991
Template	B747-200F		2	31	Main	736	True	12591
			2	31	Forward	102	True	2039
			2	31	Aft	114	True	991
Template	B747-200P		2	31	Main	736	False	
			2	31	Forward	102	True	2039
			2	31	Aft	114	True	991
Template	B747-300F		2	31	Main	736*	True	*
			2	31	Forward	102*	True	2039*
			2	31	Aft	114*	True	991*
Template	B747-300P		2	31	Main	736*	False	
			2	31	Forward	102*	True	2039*
			2	31	Aft	114*	True	991*
Template	B747-400BCF	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Template	B747-400C		2	31	Main	326	False	
			2	31	Forward	102	False	2988
			2	31	Aft	114	False	2268
Template	B747-400F	3 Pack	2	31	Main	736	True	11880
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Template	B747-400F	2 Pack	2	31	Main	736	True	7510
			2	31	Forward	102	False	2988*
			2	31	Aft	114	True	2268
Template	B747-400P		2	31	Main	736	False	
			2	31	Forward	102	True	2988
			2	31	Aft	114	True	2268
Template	B767-200P		5	24	Main	1*	False	
			5	24	Forward	66	True	1113
			5	24	Aft	73	True	510
Template	B767-300GMF		5	24	Main	429	True	9433
			5	24	Forward	87	True	1108
			5	24	Aft	98	False	
Template	B767-300P		5	24	Main	1*	False	
			5	24	Forward	87	True	1108
			5	24	Aft	98	False	
Template	B777-200P		5	27	Main	1*	False	
			5	27	Forward	76	True	2037
			5	27	Aft	80	False	
Template	B777-300P		5	27	Main	1*	False	
			5	27	Forward	103	True	2041
			5	27	Aft	113	False	
Template	B787-8							
Template	MD11F		4	21	Main	504	True	6797
			4	21	Forward	82	False	
			4	21	Aft	63	False	
UPS	B747-400F	3 Pack	2	31	Main	736	False	11880
			2	31	Forward	102	False	2988

			2	31	Aft	114	False	2268
UPS	MD11F		4	21	Main	504	False	6797
			4	21	Forward	82	False	
			4	21	Aft	63	False	

Data with an "*" has been loaded in order to generate a hold position or ventilation rate and is generally contained in aircraft or holds that are not currently used for stock transport. They would require validation if ever used. Alternatively they can simply be removed. It is advisable however to leave Templates unaltered so that information is available in the future.

Note that only aircraft that are currently used for livestock transport are found in this list. It will need to be expanded as Participants utilise other operators and their associated aircraft

9.3 Appendix 3 – Equation Flow Chart



9.4 Appendix 4 - Industry Consultation Outcomes

Industry Consultation Outcomes
LATSA V2.0

Version 1.1 = 07/12/2010

Introduction/Background

EnviroAg Australia was asked to undertake industry consultation as part of a variation to the MLA project W.LIV 0269. The outcomes of this process are included in this briefing note and are split into two parts being those that fall within the scope of the project and those that are considered additional to the process.

Industry consultation commenced on 15th November 2010 and was completed on 29th November 2010. All findings noted in face to face training sessions and interactions are recorded below.

It should be noted that meeting occurred in the order presented and that similar requests were made in many instance however they have not been repeated in the findings.

Consignment Edit

The following points were raised by Exporter 1:

- *There needs to be a Search function in the Embarkation and Destination fields or at least a first letter find function;*
- *Limit the Embarkation field to Australian Airports;*
- *The select Date and Time layout is confusing and needs some attention;*
- *Consignments should be ordered by Consignment Number;*
- *A departure date column could be added to the consignment list; and,*
- *Consignment ID is not required on screen.*

The following additional points were raised by Exporter 2:

- *Order Consignments by personalised Consignment No.;*

The following additional points were raised by Exporter 3:

- *Consignment Numbers to contain any and all characters and operators;*
- *Would like to see Departure Airports limited to Australian and New Zealand ports;*
- *Add Total Liveweight to the calculated values;*
- *Uses an Apple Laptop.*

The following additional points were raised by Exporter 4:

- *Uses Windows Vista.*

The following additional points were raised by Exporter 5:

- *Inclusion of Technical (Tech) Stops as a stop-over for re-fueling as against a Transhipment (change of planes);*
- *Need to address how to handle Transhipments – suggests linking two consignments (A & B);*
- *Copy function for different legs of transhipments;*
- *Date selection may be easier to understand and use if it appears as a control button;*
- *Uses Windows 7.*

Consignment Design

The following points were raised by Exporter 1:

- *Some crates carry multiple species and multiple average weights. These can be separated by tier so there needs to be some consideration for this;*
- *May need to load animals by tiers rather than crates;*
- *Animal Details needs to be changed to Crate Details;*
- *The update function in a loadline does not seem to work first time – it would appear you have to update twice to get it to work and sometimes the system automatically logs you out;*
- *Using Internet Explorer 7.0.5730.13;*
- *On the second NEW loadline entry the following message appeared:*
- *"ServerMethodNotImplemented. Could not find a method named "UpdatePanel" with the specified parameters";*
- *It would be more efficient if "Enter" = "Update" OR better still "Move to next entry cell";*
- *As well as having an estimated number of crates required to hold a given number of livestock there also needs to be a maximum number of livestock required to fill a given number of crates. This is calculated by:*
  Maximum number of Livestock = No. Stock Per Crate (@ ASEL) X No. Of Crates (Entered in Crate Details)
  This will yield a specified number of crates fully loaded to ASEL density;
- *Need to instigate round DOWN (<0.5) and round UP (>0.50) for the Number of Livestock Per Crate. Note that rounding creates anomalies in the final comparison of Actual to ASEL stocking density. This needs to be accounted for by comparing both the ASEL / Actual Densities AND the Entered number of stock / Maximum number of stock (as above);*
- *Need to instigate a 10% default ASEL Reduction for all Lower Deck loadlines;*
- *Need to record TRANSHIPMENT details including flight numbers, arrival and departure times. This can also calculate on ground time for the NOI form;*
- *A load of goats can exceed the temperature parameters before reaching maximum gross weight – may need to consider reducing the behaviour factor. For example a load of*

2400 goats @ 30kg in the Main deck will push the temperature to 30°C but not exceed the maximum load capacity of the plane (B747-400). The anecdotal evidence says that the cabin temperature does not exceed 28°C;

- *Need to instigate floor area reductions in the top tier of contoured multi-tiered crates – a defined application by AQIS is required;*
- *The Exit RH% appears higher than expected in a full load of goats;*
- *Could link crates and planes with standard pallets;*
- *Selection of crates is not limited by linked holds so space used appears as ZERO% when crate has not been linked. It may be better if the hold is simply not available for a particular crate;*
- *Space used calculation does not function properly e.g. (16/21 + 9/30) x 100% = 106% when in fact (16+9)/30 x 100% = 83% is the correct answer; and,*
- *Require access to Camelids and other species.*

The following additional points were raised by Exporter 2:

- *Goats appear to be drawing on the Sheep ASEL table – needs immediate correction as a full load appears to exceed the ASEL limits without good reason;*
- *Uses lower stocking rates in top decks of contoured pallets in his calculations;*
- *Would like to see automatically calculated ASEL to Actual Stocking Density ratios or similar form to his own calculation methodology;*
- *Needs some form of access to vary tier average weights or load groups of animals by tier e.g. may load more lighter (shorter) animals in top tier of a three tier crate to utilise more space;*
- *Stock weight/age determines the stocking density on the upper tier of contoured crates not the available full headroom plus a portion of the reduced height;*
- *Uses different gross weights to others including crate tare weight, nets, straps and an allowance for damp wood;*
- *The number of animals of a specified liveweight required to fill the specified number of crates would be of tremendous use.*

The following additional points were raised by Exporter 3:

- *Alter the word DESIGN to LOAD;*
- *Requires totals for the number of livestock and crates on the “Loadlines” Page;*
- *Total tare weight per pallet should include crate tare, pallet, straps and nets and the suggested addition is 135kg per crate above the crate tare.*
- *Rounding up and down must include a condition allowing the “Actual Stocking Density” to vary against ASEL without error (e.g. < 5% or 10% variation);*
- *Space used is not functioning correctly and needs attention;*
- *Requires the exit temperature to more accurately reflect load conditions;*
- *ECS Result should be altered from “Acceptable Temperature” to “Acceptable Ventilation Conditions in this hold” – this may require a combination of Temperature, Moisture and CO_2 limits and appropriate result responses.*

The following additional points were raised by Exporter 4:

- *Would be beneficial to instigate more lockouts/selection restrictions within the system;*
- *Would like to see a process simplification i.e. the use of a next function instead of going back the forwards within the structure of the program. He suggested a "NEXT" button;*
- *The recalculate button may needs to be removed and included within the update function in the loadlines (to help simplify the processing of data);*

The following additional points were raised by Exporter 5:

- *Moisture and condensation are of particular issue, the program indicates high humidity when carrying full loads. The assumptions regarding evaporation or moisture from urine and excrement in crates may need more consideration;*
- *Tech Stops in Darwin can result in high hold temperatures which can take up to 3 hours to stabilise but temperatures do subside more than indicated in the model;*
- *Cabin temperatures are often several degrees less than the program predicts but there is a noticeable difference between the front of the main deck and the rear e.g. 10^0C to 26^0C.*

Consignment Documents

The following points were raised by Exporter 1:

- *Need to reassess the wording of the questions so that a tick (check) means YES;*
- *On any document we need to assess basis of aircraft, carrier and operator approval as non listed carriers can get special inclusion;*
- *Need to reassess what is presented in regard to ECS result on all AQIS bound reports. The suggestion is to list the outcomes – Temperature, Moisture and CO_2 or reset the controlling constants so that all empirically acceptable loads pass the temperature test;*
- *We do not use the Aircraft & Ground Handling Checklist;*
- *We do use the Aircraft Lower Deck Checklist;*
- *Transhipment details are required on the Lower Deck Checklist if transhipments are selected as YES;*
- *Crate floor space details are required on the lower Deck Checklist but are listed as square meters per deck (tier);*
- *Crate headroom details are required on the Lower Deck Checklist and this could be stored in the loadline "Load Details" for extraction; and,*
- *Need to include the Carriers Main Deck Ventilation Declaration but there appears to be much duplication across all the forms.*

The following additional points were raised by Exporter 3:

- *Does not think the Aircraft Ground Handling or Lower Deck checklist are necessary;*
- *Does not believe the checklist is required given the program controls many of the available functions;*
- *Expand the Exporters report so that it alone meets AQIS' needs;*
- *Include Liveweight and Gross Weight on Exporters Report;*
- *Wants totals for the number of livestock and crates to appear on the Exporters Report.*

Administrative Requirements

The following points were raised by Exporter 3:

- *There needs to be a Carrier/Operator validation of the system data. This could come in the form of a tabulation of currently held data which is exported to an Excel worksheet and sent to the Carrier/Operator for sign-off;*
- *For new carriers there needs to be a generic list of data requirements for addition to the database;*
- *The same applies for Stock Crate Manufacturers and Crate Designs;*
- *System maintenance must be discussed at a corporate level to determine who manages the system;*
- *Access to system constants is required for proper administration:*
    - *Behaviour factor*
    - *Aircraft Skin Heat Loss (not included at this stage)*
    - *Evaporation Co-efficient*
- *A NULL field should revert to zero.*

Requested changes within the scope of the project

Consignment Edit

- *Consignments should be ordered by the personalised Consignment Number which can contain any character or operator and be more than 10 characters long (suggested 30);*
- *Consignment ID is not required on the edit screen.*
- *The "Select Date" function is confusing and needs some attention. Suggest that the date selection can only be done from the calendar or similar and the "Select Date" is a command button like "Update" or drop down arrow like Time;*
- *Add Total Liveweight to the calculated values;*
- *A departure date column may be useful in the opening consignment list page;*
- *A consignment copy function would be very useful for identical shipments and for additional legs transhipments;*
- *There needs to be a Search function in the Embarkation and Destination fields or at least a first letter find function;*
- *Would like to limit the Embarkation field to Australian and New Zealand Airports;*
- *Inclusion of Technical (Tech) Stops as a stop-over for re-fueling as against a Transhipment (change of planes);*
- *Participants desire a process simplification, particularly for new users that direct them more easily through the process. This may be accomplished but the addition of a NEXT structure that encompasses several control functions within a single control button. While-ever the programming issues remain relatively simple this can be incorporated as a "within scope" function. For more complex issues see Section 0*

Consignment Design

- *Alter the word "DESIGN" to "LOAD";*
- *Incorporate a NEXT function to guide users through the process;*
- *ANIMAL DETAILS needs to be changed to CRATE DETAILS;*
- *The update function in a Loadline does not seem to work first time – it would appear you have to update twice to get it to work and sometimes the system automatically logs you out;*
- *As well as having an estimated number of crates required to hold a given number of livestock there also needs to be a maximum number of livestock required to fill a given number of crates. This is calculated by:*
  Maximum number of Livestock = No. Stock Per Crate (@ ASEL) X No. Of Crates (Entered in Crate Details)
  This will yield a specified number of crates fully loaded to ASEL density;
- *Need to instigate round DOWN (<0.5) and round UP (>0.50) for the Number of Livestock per Crate. Note that rounding creates anomalies in the final comparison of Actual to ASEL stocking density. This must include a condition allowing the "Actual Stocking Density" to vary against ASEL without error (e.g. <5% or 10% variation);*
- *Goats appear to be drawing on the ASEL Sheep data – this needs immediate correction as a full load appears to exceed the ASEL limits without good reason;*
- *The exit temperature must more accurately reflect real load conditions. A BEHAVIOUR FACTOR is built into the administration area which affects the total heat production currently defaulted to 50% above normal (calm) conditions;*

  - *A load of 2400 goats @ 30kg in the Main deck will push the temperature to 30^oC (UCT=28^oC) but not exceed the maximum load capacity of the plane (B747-400). The anecdotal evidence says that the cabin temperature does not exceed 28^oC when fully loaded with goats;*
- *In addition the program errs on the side of caution and it must be noted that the EXIT conditions are NOT the average conditions in the cabin.*
- *The Exit RH% appears higher than expected in a full load of goats (and possibly for other animals as well). The program utilises the stocking density, a fixed Evaporation Co-efficient and an estimate of moisture deficit in the airflow to calculate moisture from manure/urine per head. The coefficient is based on pan evaporation and could be varied however its effect on total moisture load is currently less than 10%. Therefore moisture from manure/urine is not considered overly important.*
- *The majority of the moisture load comes from the latent heat calculations for each species in the cabin environment. Latent heat calculations include the Behaviour factor (currently defaulted to 50%). Decreasing the Behaviour factor will lower both the cabin temperature and consequentially the moisture load;*
- *Reducing the Behaviour factor from 50% to 10% to 0% has the following effect on a load of 2400 goats in a Boeing 747-400F:*
  - *Temperature from 29.7^0C to 27.6^0C to 26.8^0C*
  - *RH from 69% to 57% to 53%*
  - *CO_2 from 3469ppm to 2732ppm to 2472ppm*
- *Adjusting the Behaviour factor would correct all factors simultaneously and provide a predicted outcome closer to actual results but validation with empirical results is essential across a number of operators. Participants pointed out that some operators are better than others at in-flight animal management and fully utilise ESC systems to control animal behaviour. Using the best case (i.e. 0%) may not be appropriate for all operators;*
- *Space used calculation does not function properly e.g. (16/21 + 9/30) x 100% = 106% when in fact (16+9)/30 x 100% = 83% is the correct answer. The space used is based on information provided by Crate Manufacturers and not aircraft operators so could be incorrect;*
- *Adjust Crate Tare Weight to Total Tare Weight and include including crate tare weight, nets, straps and an allowance for damp wood. This is estimated to be an additional 135kg;*
- *Add the total for the number of livestock and crates on the “Loadlines” Page;*
- *ECS Result should be altered from “Acceptable Temperature” to “Acceptable Ventilation Conditions in this hold” – this may require a combination of Temperature, Moisture and CO_2 limits and appropriate result responses.*
- *The RECALCULATE button causes some difficulty in operation and consideration should be made of incorporating it in the update or NEXT function;*

Consignment Documents

- *Alter ECS result on all AQIS bound reports. "Acceptable Temperatures" to be replaced by "Acceptable Ventilation Conditions" – therefore humidity and CO_2 limits may need consideration and inclusion.*
- *Participants want the Total Liveweight, Total Gross Weight and Total Number of Crates to appear on the Exporters Report;*
- *While all exporters use the Aircraft Lower Deck Checklist, several Participants believe the Aircraft Ground Handling and Lower Deck checklists are unnecessary. These could be replaced by a single report (the Exporter Report) with the program controlling all other regulated functions. The Exporters Report could be expanded to meet AQIS' needs as a single report;*
- *Crate floor space details are required on the Aircraft Lower Deck Checklist and should be listed as square meters per deck (tier);*
- *The Carrier/Operator Aircraft Ventilation Authorisation is in use but could be removed if the program is accepted and correctly administered.*
- *If any of the documentation CHECKS are necessary then the wording of the questions should be adjusted so that a tick (check) means - YES;*
- *In addition to valid Aircraft, Carrier and Operator approval processes, Crate Certification and Manufacturer Registration numbers will be necessary to provide evidence to AQIS of efficient industry self regulation.*

Requested changes outside the scope of the project
Consignment Edit

- *Need to address how to handle Transhipments – it has been suggested that two similar consignments be linked in some manner. An existing alternative to programming is that two consignments bear the same number but with a final digit difference;*
- *While an attempt will be made to include a simple NEXT function into the software any complex system is considered to be an out of scope issue.*

Consignment Design

- *Some crates carry multiple species and multiple average weights. These can be separated by tier so there needs to be some consideration for this;*
- *May need to load animals by tiers rather than crates;*
- *It would be more efficient if "Enter" = "Update" OR better still "Move to next entry cell";*
- *While a manual ASEL reduction function now exists in each loadline as per the objectives, there may be a need to instigate a mandatory 10% default ASEL Reduction for all Lower Deck loadlines. This may come up in discussions with AQIS;*
- *Need to record TRANSHIPMENT details including flight numbers, arrival and departure times. This can also calculate on ground time for the NOI form;*
- *Need to instigate floor area reductions in the top tier of contoured multi-tiered crates. The available floor area will also vary with the height of the animal – a defined application by AQIS is required;*
- *Crates and Planes could be linked by standard pallets/ULD's which may help resolve the space used issue and the maximum number per hold information required from Crate Manufacturers;*
- *The selection of crates is not limited by linked holds so space used appears as ZERO% when crate has not been linked. It may be better if the hold is simply not available for a particular crate;*
- *Would like to Camelids and other species;*
- *Would like to see automatically calculated ASEL to Actual Stocking Density ratios or similar to support arguments with AQIS about stocking density results;*
- *Needs some form of access to vary tier average weights or load groups of animals by tier e.g. may load more lighter (shorter) animals in top tier of a three tier crate to utilise more space;*
- *Stock weight/age determines the stocking density on the upper tier of contoured crates not the available full headroom plus a portion of the reduced height;*
- *Would be beneficial to instigate more lockouts/selection restrictions in general within the system;*
- *Cabin temperatures are often several degrees less than the program predicts but there is a noticeable difference between the front of the main deck and the rear e.g. 10^0C to 26^0C. The program does not attempt to undertake complex ventilation modelling and if this were required other software may be necessary;*
- *Tech Stops in Darwin can result in high hold temperatures which can take up to 3 hours to stabilise but temperatures do subside more than indicated in the model. The program is designed only to analyse steady state in-flight conditions. Complex modelling is within the objectives of the project, however the adjustment of the Behaviour factor will alter the outcome;*

- *Moisture and condensation are of particular issue, the program indicates quite high humidity when carrying full loads. The assumptions regarding evaporation of moisture from urine and excrement in crates may need more consideration. Empirical measurement will be required in order to alter the model. For now an adjustment constant could be inserted into the crate floor area to adjust the evaporation rate;*

Consignment Documents

- *On any document we need to assess basis of aircraft, carrier and operator approval as non listed carriers can get special inclusion;*
- *Transhipment details are required on the Lower Deck Checklist if transhipments are selected as YES. This would require some form of consignment linkage;*
- *Crate headroom details are required on the Lower Deck Checklist and this could be stored in the Loadline "Load Details" for extraction.*

Administrative Requirements

- *There needs to be a Carrier/Operator validation of the system data. This could come in the form of a tabulation of currently held data which is exported to an Excel worksheet and sent to the Carrier/Operator for sign-off;*
- *For new carriers there needs to be a generic list of data requirements for addition to the database;*
- *The same applies for Stock Crate Manufacturers and Crate Designs;*
- *System maintenance must be discussed at a corporate level to determine who manages the system. This includes Crate Certification, Manufacturer Registration and LATSA Administration;*
- *Access to system constants is required for proper administration:*
    - *Behaviour factor*
    - *Aircraft Skin Heat Loss (not included at this stage)*
    - *Evaporation Co-efficient (not included at this stage)*
    - *Others as appropriate*
- *A NULL field should revert to zero.*
- *Resorting of Crates Data is required.*

Conclusion/Recommendation

All items listed in Section 9.4 above and agreed to by MLA were instigated by EnviroAg in the manner described in Section 9.5 Appendix 5 - Completion of within scope changes. A trial period was to follow. This was to involve those participants who raised issues above as well as opening the software up to general industry Participants for additional comment. A further meeting would be held before the program is presented to AQIS as a valid and systematic resolution to the issue of industry regulation of the critical factors relating to airfreight of livestock.

9.5 Appendix 5 - Completion of within scope changes

Completion of within scope changes
LATSA V2.0

Version 1 – 25/02/2011

Introduction

As a result of industry consultation, a series of changes were required in order that LASTA V2.0 can be released for general use in the lead up to discussions with AQIS. These changes were listed in Section 6 of *W.LIV.0269 Industry Consultation Outcomes 15-12-10*.

The required changes are repeated in this note together with the status of the correction applied in the program. The status comments are listed under each requirement and are formatted in *italics*.

Requested changes within the scope of the project
Consignment Edit

- Consignments should be ordered by the personalised Consignment Number which can contain any character or operator and be more than 10 characters long (suggested 30);

  The Ordering of Consignments is now in is has been completed and implemented. The order is firstly numeric the by alphabetic character. You may store a consignment code of up to 50 characters.

- Consignment ID is not required on the edit screen.

  The consignment ID has been removed from all screens and reports.

- The “Select Date” function is confusing and needs some attention. Suggest that the date selection can only be done from the calendar or similar and the “Select Date” is a command button like “Update” or drop down arrow like Time;

  The program is set to allow date entry only by selecting the appropriate date off the calendar. The time selection remains as it was via a 24 hour vertical listing for both hours and minutes. This process appears to have resolved issues with incorrect formatting and other inconsistencies.

- Add Total Liveweight to the calculated values;

  This has been added and not appears on the Load Page under Calculated Values beneath Gross Weight.

- A departure date column may be useful in the opening consignment list page;

  This has been added as the second column however you are not able to sort by this column in this Version. Consignments are ordered only by consignment number.

- A consignment copy function would be very useful for identical shipments and for additional legs transhipments;

  The consignment copy function is now found on the opening consignment page in each line following Load and Docs.

- There needs to be a Search function in the Embarkation and Destination fields or at least a first letter find function;

  This search function has been implemented. You can now start typing and the listing will filter down to only those Airports commencing with the letters you have entered. The search function has been extended to the Tech Stop.

- Would like to limit the Embarkation field to Australian and New Zealand Airports;

  This has been accomplished by adding a field to the Airports table. When you wish to include another embarkation port you simply "check" it and it will appear in the list. This list is limited to ONLY those airports that have been "checked" in the Administration section.

  Users will need to advise the ADMINISTRATOR if any information is incorrect or airports are missing from the list. Users should be aware that airports are named according to their IATA code and not necessarily the city in which they are located.

- Inclusion of Technical (Tech) Stops as a stop-over for re-fueling as against a Transhipment (change of planes);

  This has been added and is positioned on the Add Consigment page between the Embarkation and Destination Ports. As noted above the auto search function also works with this field.

- Participants desire a process simplification, particularly for new users that direct them more easily through the process. This may be accomplished but the addition of a NEXT structure that encompasses several control functions within a single control button. While-ever the programming issues remain relatively simple this can be incorporated as a "within scope" function.

  We have incorporate a NEXT button on each page or sub page to guide users from New Consignment through to the documentation. While the consignment is simple this appears to work effectively. However as consignments become more complex, users will have to gain more experience with the software to achieve its full potential. A user manual will be forthcoming very shortly which will provide more detailed information on the use of the program. This manual will only be useful to those who do in fact read manuals.

Consignment Design

- Alter the word “DESIGN” to “LOAD”;

  This has been changed in several places throughout the various pages of the interface. We have also reordered the words Load and Docs on the Consignment page so that movement through the program appears to flow in a similar order to the completion of the data entry process.

- Incorporate a NEXT function to guide users through the process;

  As mentioned above, this has been implemented. Users will need to determine how effect this process is against the value of a user manual. The user manual can be made available in several formats - .cmh, .htm and .pdf. In may be useful to add the help file to the website in the next version of the program but its incorporation at this stage is outside the scope of the project.

- ANIMAL DETAILS needs to be changed to CRATE DETAILS;

  This has been corrected on the LoadLines sub-page.

- The update function in a Loadline does not seem to work first time – it would appear you have to update twice to get it to work and sometimes the system automatically logs you out;

  A fix was implemented for this which appears to be functioning correctly. It is still advisable however to allow each page to fully load on your browser before attempting changes.

- As well as having an estimated number of crates required to hold a given number of livestock there also needs to be a maximum number of livestock required to fill a given number of crates. This is calculated by:

  Maximum number of Livestock = No. Stock Per Crate (@ ASEL) X No. Of Crates (Entered in Crate Details)
  This will yield a specified number of crates fully loaded to ASEL density;

  On the LoadLines sub-page we have altered the names of some fields to make it clear the intent of the data. We now have:

  - *Max Head per Crate (based on ASEL);*
  - *Crates Required (based on ASEL and the “No. of Animals” entered in Load Details);*
  - *Max Crates per Hold (to assist Users to understand the Space require result); and,*
  - *Est Stock (which is the result of Max Head per Crate X Max Crates per Hold).*

  This last value should answer the question of how many livestock of this type can the User fit in the aircraft using this crate. The correct result relies on the Administrator correctly setting up the data tables for the Crate.

- Need to instigate round DOWN (<0.5) and round UP (>0.50) for the Number of Livestock per Crate. Note that rounding creates anomalies in the final comparison of Actual to

ASEL stocking density. This must include a condition allowing the "Actual Stocking Density" to vary against ASEL without error (e.g. <5% or 10% variation);

This has been implemented. The latter issue of ASEL to Actual variation has been accomplished by comparing a rounded ASEL Density to the Actual Density. Althought the mathematics is somewhat more complicated the program basically allows the Actual Stocking Density to vary "below" ASEL by up approximately 10% before it generates an error.

- Goats appear to be drawing on the ASEL Sheep data – this needs immediate correction as a full load appears to exceed the ASEL limits without good reason;

This has been corrected and validated against ASEL tables.

- The exit temperature must more accurately reflect real load conditions. A BEHAVIOUR FACTOR is built into the administration area which affects the total heat production currently defaulted to 50% above normal (calm) conditions;

The EXIT temperature is the maximum temperature at the exit point and not the average across the hold. Some areas of the hold directly under outlets may be quite cool. This is why care should be taken in ventilation distribution within the aircraft (as we don't want animals too cold either). The reduction of the Behaviour factor does in fact reduce the Exit temperature value. Whilst it is now closer to that experienced in practice it is not considered appropriate to modify it further without adequate monitoring data to make accurate analytical decisions.

- A load of 2400 goats @ 30kg in the Main deck will push the temperature to 30oC (UCT=28oC) but not exceed the maximum load capacity of the plane (B747-400). The anecdotal evidence says that the cabin temperature does not exceed 28oC when fully loaded with goats;

The correction of the ASEL curve and the reduction of the behaviour factor appear to have resolved this issue. A further issue was noted in testing whereby the humidity used in determining the UCT selection was being draw from the incorrect field. This only affected the result when the Administrator adjusted the maximum RH to 80% or above This has been corrected and the program now uses the calculated RH of the respective hold.

Those acceptable consignments that were creating errors in the past no longer present as failed cases.

- In addition the program errs on the side of caution and it must be noted that the EXIT conditions are NOT the average conditions in the cabin.

This was included as a note. It must be mentioned that the resultant hold temperature, while under the Min UCT, may be marginally higher than in practice. See above.

- The Exit RH% appears higher than expected in a full load of goats (and possibly for other animals as well). The program utilises the stocking density, a fixed Evaporation Co-efficient and an estimate of moisture deficit in the airflow to calculate moisture from manure/urine per head. The coefficient is based on pan evaporation and could be varied however its effect on total moisture load is currently less than 10%. Therefore moisture from manure/urine is not considered overly important.

This has corrected itself through the changes in ASEL curve data and the reduction of the Behaviour factor.

- The majority of the moisture load comes from the latent heat calculations for each species in the cabin environment. Latent heat calculations include the Behaviour factor (currently defaulted to 50%). Decreasing the Behaviour factor will lower both the cabin temperature and consequentially the moisture load;

As above the reduction of the Behaviour factor has provided the desired reductions in all calculated results.

- Reducing the Behaviour factor from 50% to 10% to 0% has the following effect on a load of 2400 goats in a Boeing 747-400F:
    - Temperature from 29.70C to 27.60C to 26.80C
    - RH from 69% to 57% to 53%
    - CO2 from 3469ppm to 2732ppm to 2472ppm

The decision was taken to set the Behaviour factor to 10%. This has been implemented as above. The correction of the ASEL stocking densities for goats has also assisted.

- Adjusting the Behaviour factor would correct all factors simultaneously and provide a predicted outcome closer to actual results but validation with empirical results is essential across a number of operators. Participants pointed out that some operators are better than others at in-flight animal management and fully utilise ESC systems to control animal behaviour. Using the best case (i.e. 0%) may not be appropriate for all operators;

See above.

- Space used calculation does not function properly e.g. (16/21 + 9/30) x 100% = 106% when in fact (16+9)/30 x 100% = 83% is the correct answer. The space used is based on information provided by Crate Manufacturers and not aircraft operators so could be incorrect;

This is very problematic in this version. The program stores the data for the number of crates fitting various aircraft with the crates. If is rather more complex to achieve the result above and would require far more code. We have elected to take a simple approach.

The maximum number of particular crates allowed in a specific hold will appear on the LoadLines sub-page. This is to assist Users to determine the maximum head of stock that can be loaded in this number of crates.

The space calculation in the Environmental Results will not fault if over 100% but appear orange suggesting that the User should check what they are doing as they have potentially assigned more crates than are allowed. The program WILL now error if the space used is ZERO%. This is because the crate has not been assigned to this hold by the Administrator. The User should then contact the Administrator to ensure it is assigned. It will then be available for all Users.

We envisage that a more accurate solution can be applied in the next Version but it requires additional linked tables and a significant change to the code.

- Adjust Crate Tare Weight to Total Tare Weight and include including crate tare weight, nets, straps and an allowance for damp wood. This is estimated to be an additional 135kg;

The wording has been set to Tare (kg). The Administration and User Manuals will both refer to the Crate Tare Weight as an inclusive value i.e. that it includes the weight of the crate, pallet, nets and straps for which it is designed. The additional weight factor above the Crate tare is 135kg across all crates.

- Add the total for the number of livestock and crates on the “Loadlines” Page;

This has been accomplished by grouping animals on the Consignment (Edit) page. The program totalises both the number of animals and the number of crates. The program does not differentiate between different crates and holds.

- ECS Result should be altered from “Acceptable Temperature” to “Acceptable Ventilation Conditions in this hold” – this may require a combination of Temperature, Moisture and CO2 limits and appropriate result responses.

This has been corrected. In addition we have included sub warnings for each of Temperature, Moisture and CO_2.

- The RECALCULATE button causes some difficulty in operation and consideration should be made of incorporating it in the update or NEXT function;

A fix was implemented which has corrected the problem. Use of the NEXT button in the LoadLine sub-page does force the program to re-calculate.

Consignment Documents

- Alter ECS result on all AQIS bound reports. "Acceptable Temperatures" to be replaced by "Acceptable Ventilation Conditions" – therefore humidity and CO2 limits may need consideration and inclusion.

  This has been corrected. In addition we have included sub warnings for each of Temperature, Moisture and CO_2.

- Participants want the Total Liveweight, Total Gross Weight and Total Number of Crates to appear on the Exporters Report;

  The following results now appear on the top right of the Exporter Report:
    - *Total Number of Crates;*
    - *Total Gross Weight; and,*
    - *Total Live Weight*

  In addition the table in the Exporters Report provides:
    - *The Total Number of Livestock; and,*
    - *The Total Number of Crates*

- While all exporters use the Aircraft Lower Deck Checklist, several Participants believe the Aircraft Ground Handling and Lower Deck checklists are unnecessary. These could be replaced by a single report (the Exporter Report) with the program controlling all other regulated functions. The Exporters Report could be expanded to meet AQIS' needs as a single report;

  The "Aircraft and Ground Handling Checklist" has been combined with the "Lower Deck Checklist". Where lower holds are used, additional information or provision for hand written details will appear on the report. The same can be said if the load is to be transhipped.

  The Exporters Report will remain (basically)unaltered until the meeting with AQIS

- Crate floor space details are required on the Aircraft Lower Deck Checklist and should be listed as square meters per deck (tier);

  Allowance for manual entry of this information will appear on the Aircraft and Ground Handling Checklist if a lower hold is in use.

- The Carrier/Operator Aircraft Ventilation Authorisation is in use but could be removed if the program is accepted and correctly administered.

  This may only be actioned in discussion with AQIS. No provision for the viewing and printing of this document has been provided in LATSA V2.0

- If any of the documentation CHECKS are necessary then the wording of the questions should be adjusted so that a tick (check) means - YES;

  This has been implemented for the two remaining questions:

- **Are there any Aircraft Operational Limitations, MEL/DDG open items affecting ECS systems?**
- **Are there any Transhipments?**

A tick in the checkbox means YES. If the checkbox is ticked an error message will appear for the first question and additional information will appear on the Checklist for the second.

- In addition to valid Aircraft, Carrier and Operator approval processes, Crate Certification and Manufacturer Registration numbers will be necessary to provide evidence to AQIS of efficient industry self regulation.

This part of the process is currently in the control LiveCorp. All currently available data has been loaded into the system.

Conclusion/Recommendation

EnviroAg Australia believes that all points have now been satisfactorily addressed. The corrections applied provide an adequate solution. As the project has reached a release point it would seem appropriate to allow Users general access to it.

In order to effect additional and significant changes e.g. provide “precise” space used results or upgrade the documentation to print total aircraft floor space, total tier space etc., it is necessary to build new tables and make significant changes to the code. These types of requests fall outside of the original scope of the project and it would be expected that they be carried over to a new Version.

While we may be very confident that this tool and the preceding projects meet most if not all of the current AQIS requirements, it would seem appropriate that the industry firstly seek the general approval of AQIS as to this solution before investing more capital to further develop the tool.

9.6 Appendix 6 – Additional Industry Comment

Aerospace Developments Pty. Ltd.
ABN: 20-002-728-798
Phone/Fax: 61 2 9428 4382; Mobile 61 418 (0418) 302 001
Email: dirigible@msn.com.au
106 Riverview Street, Riverview 2066, NSW. Australia

May 31st. 2011

Mr David Beatty
Live Export R & D Manager
Meat & Livestock Australia Limited
Level 1 165 Walker Street
North Sydney NSW 2060

Dear David,

Re: LATSA II program audit findings

We have completed a brief audit review of the Software application (only) of the new LATSA II Program software as presented to the LiveAir AGM. This audit did not include the assessment /analysis and voracity or accuracy of the data used to formulate the models or examples used to develop the program as shown in the PowerPoint presentation at the AGM.

In brief, the results on the attachment from Exotan International highlight some major issues that render the program almost un-useable if you are required to make up an accurate shipment profile, some of these include:

- Item 1. Describes the C# .Net language as suitable.
- Item2. There should be some concern of the usernames and password being unencrypted.
- Item 3. This was one of many aircraft type (Boeing747-300 Freighter) examples that highlighted the following issues:
    - *a. Carrier and Operator are not searchable;* this makes it very awkward and time consuming to the exporter or operator to complete the document.
    - *b. Embarkation, Tech Stop & Destination selections are searchable;* this is OK.
    - *c. ECL, Consignee & Flight No: are all free texts;* these should be OK, however would require some control in data entry.
    - *d. There is no checking of Embarkation Date and Destination Date. i.e.: It is possible to fly from Sydney to Amsterdam in 9 hours? ;* This is completely unacceptable as apart from the shipper, AQIS will need to know the precise duration of the flight.
    - *e. 'Next' button seems to have some delay and sometimes locks the web page with 'Loading' ….being displayed. ;* This can result in the loss of data and repetitious actions to finalize the load.
    - *f. Overloading the main hold with 500 cattle of 200kg. Weights it creates the following error* **(Refer to attachment 1. 'Message from Web Page')** *when trying to correct to 200 cattle of 200kg. Weights.*

- *g. If the main hold is loaded correctly, then it is possible to overload the forward and aft lower holds thus enabling the plane to theoretically i.e.: 169,225kgs.;* This exceeds the maximum payload capacity of an aircraft upward of 50,000kgs. For a Boeing 747-400 freighter, and this also is simliar to all other model aircraft.(**Refer to Attachment 2. ‘Consignments >> Load ‘)**
- *h. If a passenger aircraft is selected everything goes as above until you enter the number of animals required and try and update, the then site crashes;* **(Refer to Attachment 3. ‘Server Error in ‘/’ Application’)**
- *i. Also captured a network trace of a valid transaction and found the following defects; this appears to be the cause of 3.e. “Server Error in’/’ Application”.* **(Refer to Attachment 4. ‘Response. Redirect cannot be called in a Page call back’.)** This would invalidate any data in the shipment.
- *j. When viewed the Aircraft Ground Handling Checklist and the Exporters Report are displayed on a blank grey background, there is an option to email these to a third party, there should also be an option to print as well?;*

The aforementioned points are representative of a number of samples and would make the information and required data invalid. AQIS will not be able to reconcile the validity nor the accuracy of the data, in addition the checklist is too complex and does not cover the critical key areas required for certification, the original LATSA 1 Checklist covers the required certification details and is more user friendly.

It is recommended that a revision and rewrite of the program be considered prior to presenting to AQIS, as it does not comply with the original intent and exporter requirements.

We would welcome your feedback,

Kind regards,

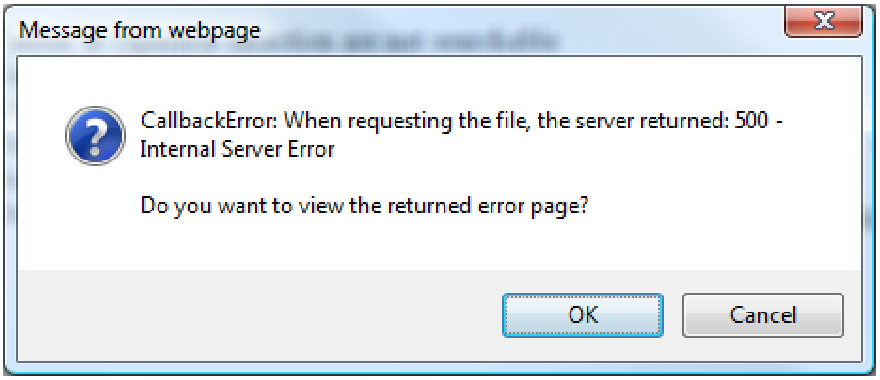
Péter Marosszéky
Director

Cc: Mr Luke Hogan
Regional Business Manager SQLD.
EnviroAg Australia Pty. Limited.
213a Ruthven Street, Toowoomba QLD 4350

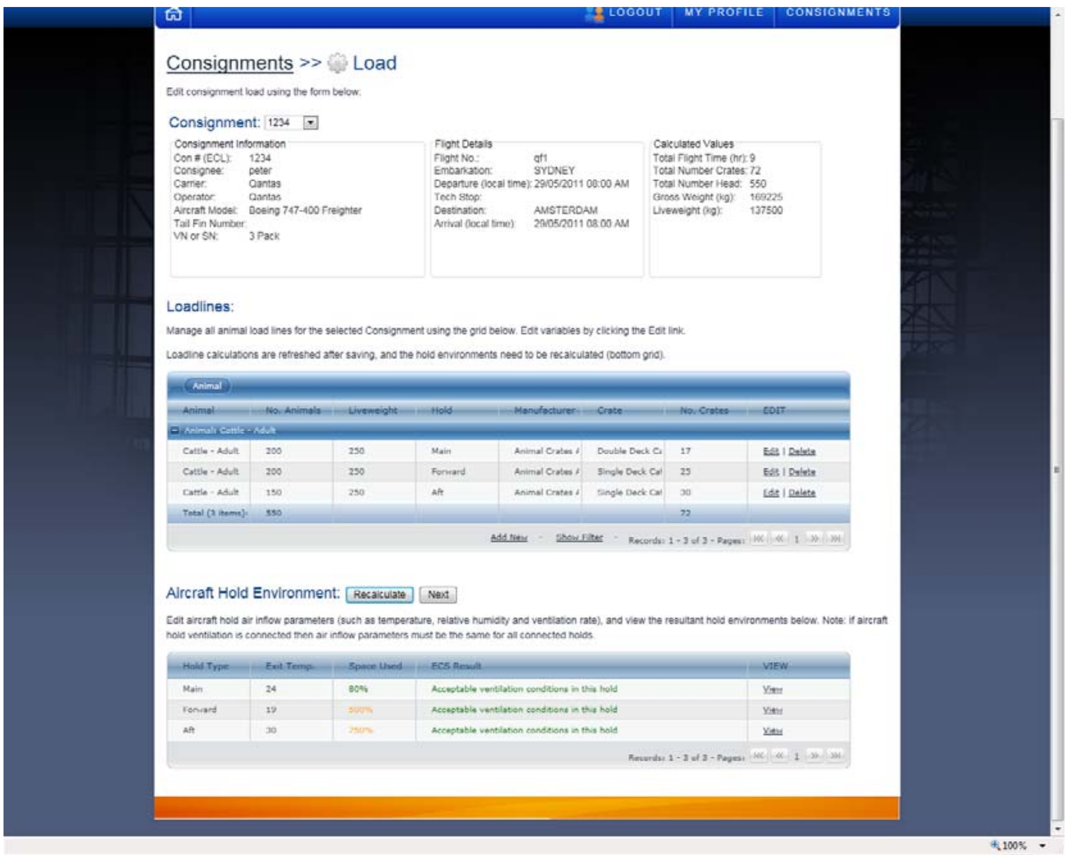
Cc: Mr Sean Salisbury
Director
Exotan International.

Attachments:

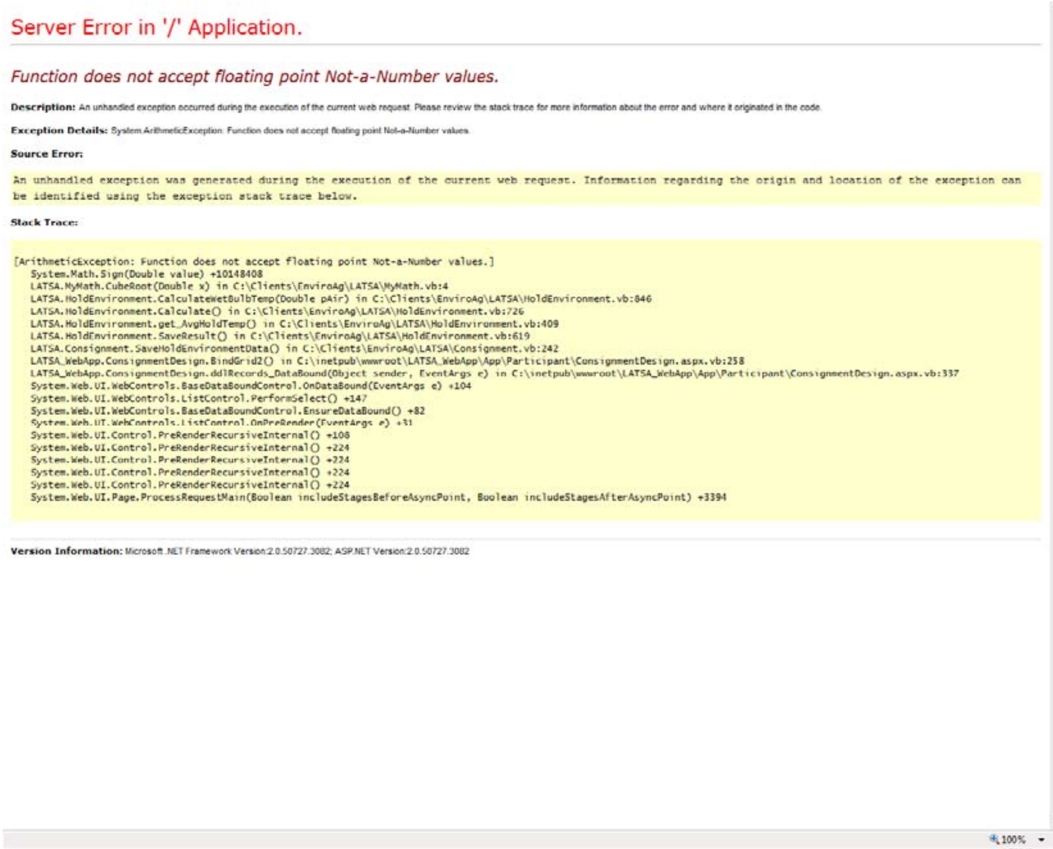
Attachment 1:



Attachment 2:



Attachment 3:



Server Error in '/' Application.

Function does not accept floating point Not-a-Number values.

Description: An unhandled exception occurred during the execution of the current web request. Please review the stack trace for more information about the error and where it originated in the code.

Exception Details: System.ArithmeticException: Function does not accept floating point Not-a-Number values.

Source Error:

```
An unhandled exception was generated during the execution of the current web request. Information regarding the origin and location of the exception can
be identified using the exception stack trace below.
```

Stack Trace:

```
[ArithmeticException: Function does not accept floating point Not-a-Number values.]
   System.Math.Sign(Double value) +10148408
   LATSA.MyMath.CubeRoot(Double x) in C:\Clients\EnviroAg\LATSA\MyMath.vb:4
   LATSA.HoldEnvironment.CalculateWetBulbTemp(Double pAir) in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:846
   LATSA.HoldEnvironment.Calculate() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:726
   LATSA.HoldEnvironment.get_AvgHoldTemp() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:409
   LATSA.HoldEnvironment.SaveResult() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:619
   LATSA.Consignment.SaveHoldEnvironmentData() in C:\Clients\EnviroAg\LATSA\Consignment.vb:242
   LATSA_WebApp.ConsignmentDesign.BindGrid2() in C:\inetpub\wwwroot\LATSA_WebApp\App\Participant\ConsignmentDesign.aspx.vb:258
   LATSA_WebApp.ConsignmentDesign.ddlRecords_DataBound(Object sender, EventArgs e) in C:\inetpub\wwwroot\LATSA_WebApp\App\Participant\ConsignmentDesign.aspx.vb:337
   System.Web.UI.WebControls.BaseDataBoundControl.OnDataBound(EventArgs e) +104
   System.Web.UI.WebControls.ListControl.PerformSelect() +147
   System.Web.UI.WebControls.BaseDataBoundControl.EnsureDataBound() +82
   System.Web.UI.WebControls.ListControl.OnPreRender(EventArgs e) +31
   System.Web.UI.Control.PreRenderRecursiveInternal() +108
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean includeStagesAfterAsyncPoint) +3394
```

Version Information: Microsoft .NET Framework Version:2.0.50727.3082; ASP.NET Version:2.0.50727.3082

100%

Attachment 4:

Response.Redirect cannot be called in a Page callback.

Description: An unhandled exception occurred during the execution of the current web request. Please review the stack trace for more information about the error and where it originated in the code.

Exception Details: System.ApplicationException: Response.Redirect cannot be called in a Page callback.

Source Error:

```
An unhandled exception was generated during the execution of the current web
request. Information regarding the origin and location of the exception can be
identified using the exception stack trace below.
```

Stack Trace:

```
[ApplicationException: Response.Redirect cannot be called in a Page callback.]
   System.Web.HttpResponse.Redirect(String url, Boolean endResponse) +11049600
   LATSA_WebApp.ConsignmentDesign.ddlRecords_SelectedIndexChanged(Object sender,
EventArgs e) in
C:\inetpub\wwwroot\LATSA_WebApp\App\Participant\ConsignmentDesign.aspx.vb:347
   System.Web.UI.WebControls.ListControl.OnSelectedIndexChanged(EventArgs e) +115
   System.Web.UI.Page.RaiseChangedEvents() +89
   System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
includeStagesAfterAsyncPoint) +2777
```

Version Information: Microsoft .NET Framework Version:2.0.50727.3082; ASP.NET Version:2.0.50727.3082

9.7 Appendix 7 – Response to Additional Industry Comment

Comments regarding the Aerospace Development's review as listed below.

It is important to note that Aerospace Developments have reviewed the participant interface based on their own scope. The specification followed by the program developers involved in version 2.0 of LATSA did not incorporate some functionality due to scope limitations. Each of the points raised by Aerospace Developments have been responded to below:

1. The encryption of usernames and passwords was not deemed necessary during development as version 2.0 of LATSA was not considered a security sensitive application (e.g. the personally identifiable information stored is very minimal and the site has no ecommerce function at this point). Encrypting usernames and passwords may be considered in version 3.0 of LATSA.

2. Earlier requests by systems testers were incorporated in searchable fields for Embarkation and Destination. Additional filtering to the Carrier and Operator fields could be considered in version 3 of LATSA.

3. Each participant will have a different management system for ECL (or consignment numbers) and Consignees. It was not considered prudent to add further limitations to the system to force Participants into new data record systems. In addition, fixing the Flight No field to the Carrier would mean significant administrative maintenance to ensure future changes to flight numbers were updated in a currently non-existent and linked table. Any change to the current system would require broad comment from industry due to the cost of ongoing data maintenance.

4. Flight Duration is currently calculated in the following manner:

   (Local Arrival Date/Time + GMT difference) – (Local Departure Date/Time + GMT difference)

   As the GMT difference for all airports are included in the Airport Table this would generally provide an effective flight duration result. Validation would require significant maintenance of an inter-port flight duration table linked to the aircraft table. This is an onerous maintenance task and is not considered necessary when the Participant would be expected to be aware of the flight duration without use of the software and can readily check the outcome.

   We are unaware of the dates and times used by Aerospace Developments to achieve a 9 hours flight duration to Amsterdam. We suspect that the Participant may not have used local time in the Arrival Time Field or applied a time which was not correct as per the flight schedule.

5. The Next buttons were introduced to assist in streamlining the process for new Participants. The “loading” message implicitly requests the Participant to wait while the current command is completed. If the Participant clicks on any buttons during this time the current process may appear locked and be aborted leaving the Participant to re-enter the information. The provision of button lock-outs or additional messaging may assist and could be considered in version 3.0 of LATSA

6. We have not been able to duplicate the error and have successfully “overloaded” the main hold of a Boeing 747-400BFC. Due to the nature of the error message presentation

we assume this error is related to server function and not to operation of the program.

7. We must advise that a decision was made by industry representatives to remove any weight loading restrictions. This decision was based on the variability of load and fuel factors and was not considered to be within the scope of this project. In addition to these comments, the Participant has no way of knowing the gross weight of other cargo when shipping less than a full plane load of livestock so weight limitations become meaningless as they are controlled by the carrier's loadmaster.

8. There were some passenger aircraft loaded into the administrative database with data for unavailable decks or with recirculation active in the ventilation table. It is possible that these aircraft were used and created this error. This data has since been removed. While there is a compliant field listed in the aircraft model and aircraft hold tables they are yet to be implemented as lockouts. It was expected to instigate further lockouts in version 3.0 of LATSA once AQIS has made comment on the current version of the program. We expect this will minimise or eliminate this potential error.

9. Attachment 4 can be caused by a timeout. Steps can be taken to prevent this in version 3.0 of LATSA.

10. Printing of Documents is achieved through the standard Brower print function. We recommend that the participant click "view" and then use File >> Print. If "File" is not an option in your browser try pressing Alt to view the menu.

11. The checklist draw from version 1.0 of LATSA was modified (and simplified to its current form) by a group of industry Participants. Until a meeting with AQIS is satisfactorily concluded this will remain as the standard reporting system in version 2.0 of LATSA.

In summary, we appreciate the comments and have attempted to effectively answer any constructive criticism of the software. We note that this analysis may have been undertaken without the use of a Participants Manual together with a copy of the final project scope and knowledge of subsequent industry decisions. This placed the system tester at some disadvantage. We would however be happy to discuss specific instances of error in order to correct operational issues or identify system constraints not previously noted. The above comments will be presented to the project manager for inclusion in any subsequent revision of the software.

9.8 Appendix 8 – LATSA V2.0 Administrators Manual

LATSA V2.0 - Administrators Manual

Introduction

Version 2 of LATSA is intended to allow livestock exporters who consign cattle, sheep, goats and camelids on aircraft flights out of Australia to:

- Plan and design their consignments to comply with ASEL standards,
- Check the spatial and weight limitations of the crates they intend to use, and
- Assess the general adequacy of the aircraft heating, ventilation and air conditioning (HVAC) system in respect to heat, moisture and carbon dioxide likely to be emitted by the animals while in transit.

Structure of LATSA V2.0

LATSA V2.0 is made up of three main components:

- Fixed and variable data which is stored in a series of SQL Data tables. The tables are named in a similar fashion to this and the User manual. The full list of tables can be found in the accompanying report on the project.
- The program written in C #, which calculates, compares and stores data relating to individual user's consignments. The source code is owned by Meat and Livestock Australia Limited.
- The Web interface which is written in .NET and (the pages of which) forms the basis of this and the ***Participant*** (or User) manual.

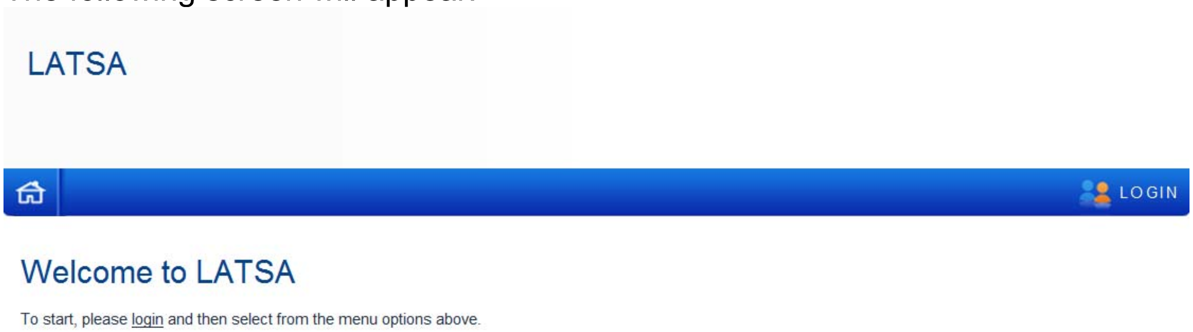
The two access areas i.e. ***Administrator*** and ***Participant*** are independent. An ***Administrator*** does not have access to ***Participant*** functions and vice versa.

Administration functions

The website is accessed by the following URL:

www.livecorp.info

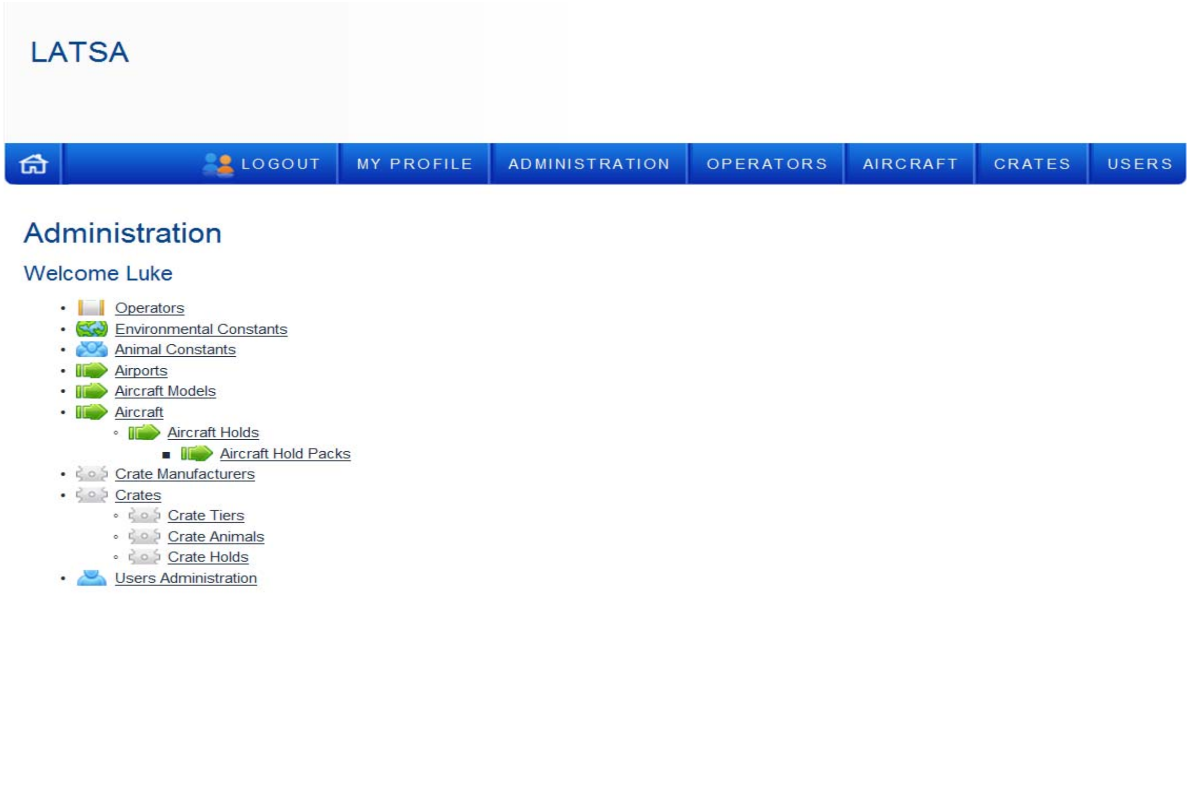
The following screen will appear:



Click on ***login*** and enter your Administrator's username and password. This will allow you access to the ***Administration*** home page below.

Administration functions can be accessed by:

- The top toolbar on the ***Administration*** page (the blue bar);
- The chart or 'tree' on the opening screen; or
- By drilling down through associated pages.


LATSA
LOGOUT
MY PROFILE
ADMINISTRATION
OPERATORS
AIRCRAFT
CRATES
USERS
Administration
Welcome Luke
Operators
Environmental Constants
Animal Constants
Airports
Aircraft Models
Aircraft
Aircraft Holds
Aircraft Hold Packs
Crate Manufacturers
Crates
Crate Tiers
Crate Animals
Crate Holds
Users Administration

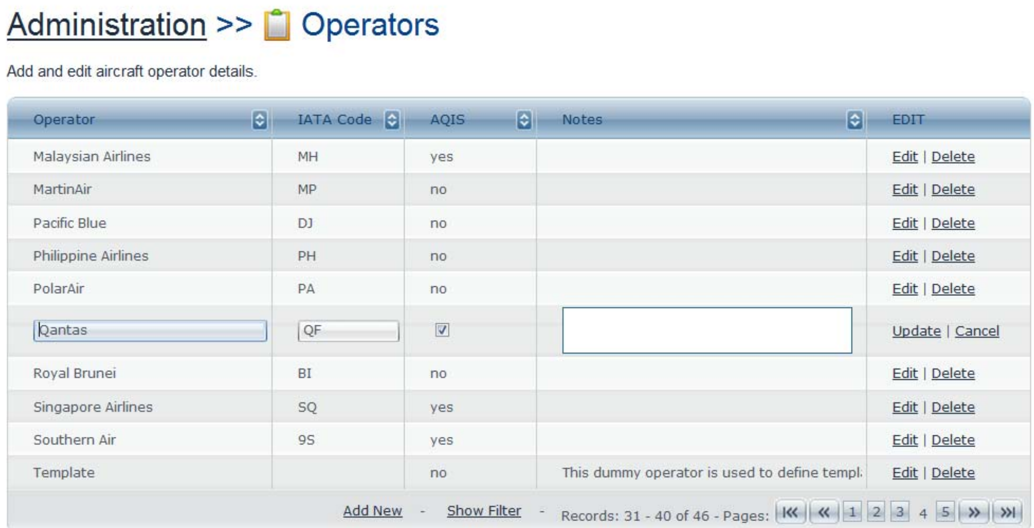
Operators

Enter the ***Operators*** page via the ***Administration*** page

For the purpose of LATSA V2.0 aircraft owners AND carriers are included in the ***Operators*** data table. An ***Operator*** may or may not own the aircraft the use in their flight operations. For this reason the main contact for Exporters (via the Participant access to the program) is considered the ***Carrier*** whilst the aircraft owner is considered to be the ***Operator***.

To add a new operator click on ***Add New*** with the ***Operators*** screen open and enter the following:

- The operator's name;
- The IATA abbreviated code for that operator;
- Tick the checkbox if this is an accredited operator for use in AQIS regulated livestock air consignments;
- Add any notes (if required); and
- Click on ***Update***.


Administration >> Operators

Add and edit aircraft operator details.

Operator	IATA Code	AQIS	Notes	EDIT
Malaysian Airlines	MH	yes		Edit | Delete
MartinAir	MP	no		Edit | Delete
Pacific Blue	DJ	no		Edit | Delete
Philippine Airlines	PH	no		Edit | Delete
PolarAir	PA	no		Edit | Delete
Qantas	QF	☑		Update | Cancel
Royal Brunei	BI	no		Edit | Delete
Singapore Airlines	SQ	yes		Edit | Delete
Southern Air	9S	yes		Edit | Delete
Template		no	This dummy operator is used to define templ:	Edit | Delete

Add New - Show Filter - Records: 31 - 40 of 46 - Pages: 1 2 3 4 5

In order to make changes to an existing ***Operator***, locate that ***Operator*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Environmental Constants

Enter the ***Environmental Constants*** page via the ***Administration*** page.

These constants are key to many calculations within the program. They either form a direct part of calculations or provide the threshold used in comparative statements. It is recommended that changes be made only after thorough consideration of the consequences of this action.

The administrator must ***Update*** any changes made in the entry boxes in order to save those changes.

Cancel with return the original values (provided they have not be Updated in the meantime).

Administration >> Environmental Constants

Edit animal and hold environment constants.

VolumeStdCrate	15.9	standard LD7 crate volume (m³)
a0	7.12	evaporation coefficient (range 7.12 to 26.6 kg/m²/hr/Pa)
RHMax	80	max relative humidity (%)
C02_Threshold	5000	Threshold CO2 (ppmv)
C02_Normal	380	Assumed normal CO2 level (ppmv)
ExcitementFactor	0.1	Excitement factor (range from 0 to 1)
HeadspaceFactor	0.2	Factor of hold volume that can be considered as Headspace (range from 0 to 1)
UsableCargoSpaceFactor	0.8	Factor of hold volume that can be considered usable for cargo (range from 0 to 1)

Update Cancel

The ExcitementFactor has a significant effect on all three of the animal outputs i.e. heat load, moisture and CO_2 production. This constant attempts to emulate the increased stress load in animals if not handled in a calm and efficient manner. A level of 0.5 (50% increase) appears to lead to significantly higher outputs than noticed in practice. As a result a decision was made by a panel of Exporters, MLA and LiveCorp representatives to reduce this factor to 0.1 (equal to a 10% increase over normal levels). Further changes must be validated by monitoring loads over time.

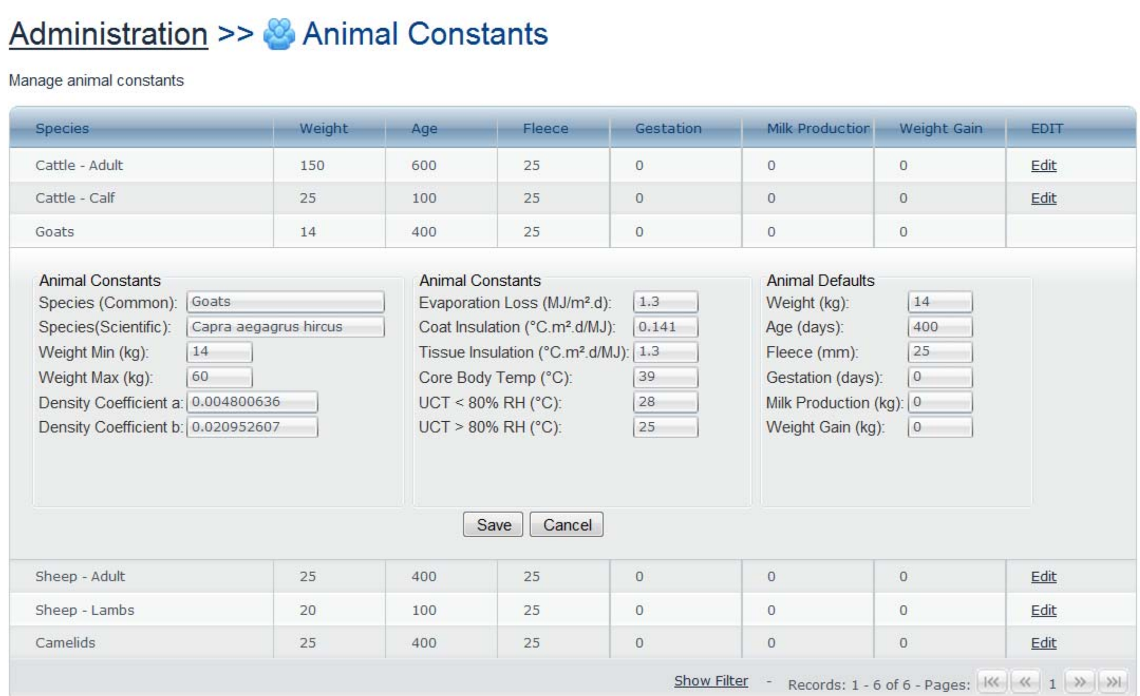
Animal Constants

Enter the ***Animal Constants*** page via the ***Administration*** page.

A series of constants have been applied to each species of animal. At this point LATSA includes Cattle, Goats Sheep and Camelids. These constants are used in the calculation of heat, moisture and CO_2 production for each group. Where the age of the animal requires a change in the value of some constants that species is divided into Adult and "young".

In this version of the program it is not possible to add or delete Species. Changes can only be made through direct entry to the appropriate data table and only by request to a competent computer programmer.

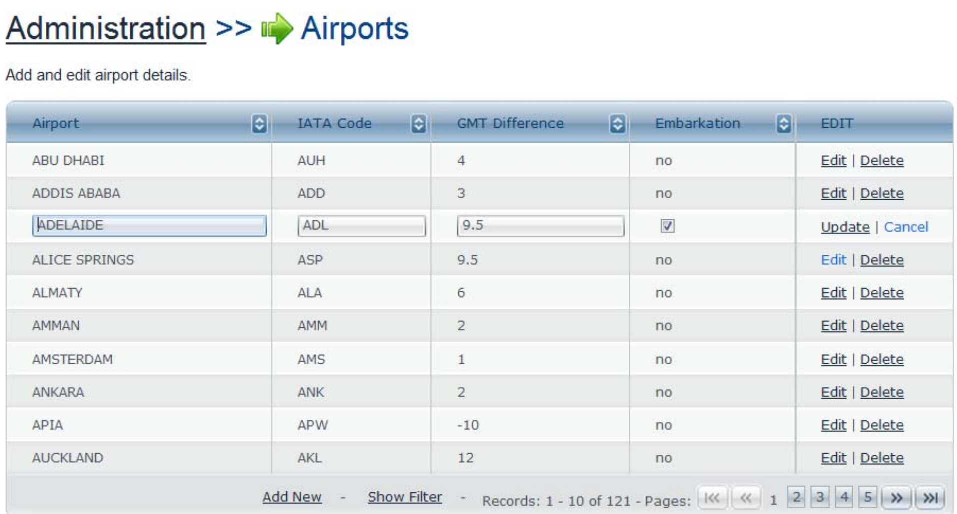
Constants may be altered and saved by overwriting the old value and pressing the ***Save*** button. Changes should only be undertaken with a thorough knowledge of the Animal calculations found in the report accompanying this project and with full awareness of the consequences. As an example, the density coefficients a and b relate to the y-interception and slope of the animal density curves found in the AQIS Live Export Regulations.



Airports

Enter the ***Airports*** page via the ***Administration*** page.

To add a new airport click on ***Add New*** with the ***Airports*** page open and enter the following:
The airport name;
- The 3-letter IATA code abbreviation for that airport;
- The time difference (± X.X hrs) between standard time (not daylight saving time) at that airport from Greenwich Mean Time; and
- Where the airport is an Australian embarkation port ***Check*** the box under ***Embarkation.*** This will ensure the airport appears in the ***Embarkation*** list in the new ***Consignment*** page for all users.
- Click on ***Update***.


Administration >> Airports

Add and edit airport details.

Airport	IATA Code	GMT Difference	Embarkation	EDIT
ABU DHABI	AUH	4	no	Edit | Delete
ADDIS ABABA	ADD	3	no	Edit | Delete
ADELAIDE	ADL	9.5	☑	Update | Cancel
ALICE SPRINGS	ASP	9.5	no	Edit | Delete
ALMATY	ALA	6	no	Edit | Delete
AMMAN	AMM	2	no	Edit | Delete
AMSTERDAM	AMS	1	no	Edit | Delete
ANKARA	ANK	2	no	Edit | Delete
APIA	APW	-10	no	Edit | Delete
AUCKLAND	AKL	12	no	Edit | Delete

Add New - Show Filter - Records: 1 - 10 of 121 - Pages: 1 2 3 4 5

In order to make changes to an existing ***Airport,*** locate that ***Airport*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Aircraft Models

Enter the ***Aircraft Models*** page via the ***Administration*** page.

Aircraft Models are used generically in the program. In turn the model name should represent the series and type of aircraft in a single line entry. As new models become available they should be entered in this list. It is not necessary to enter a model if it cannot be used in the transport of livestock but in general most planes can carry some livestock in at least one of its holds.

Passenger models that have been converted to freight planes may require a specific model name.

To add a new aircraft models click on ***Add New*** with the ***Aircraft Models*** page open and enter the following:

- The aircraft model name; and
- Click on ***Save***.

In order to make changes to an existing models, locate that model in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Aircraft

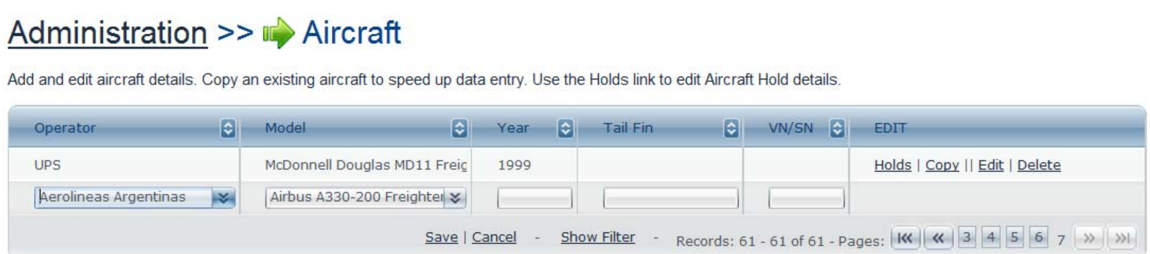
Enter the ***Aircraft*** page via the ***Administration*** page.

For the purpose of inclusion in LATSA V2.0, an ***Aircraft*** is owned by an ***Operator***. In order that a User can access and ***Aircraft*** it must have an assigned ***Operator***, ***Model*** and ***Hold*** information.

To add a new aircraft for specific operators click on ***Add New*** with the ***Aircraft*** screen open and enter the following:

- The operator's name (select from drop-down list);
- The aircraft model (select from drop-down list);
- The year of manufacture, tail fin and serial numbers (if known); and
- Click on ***Save***.

Currently insufficient information is available to populate the year of manufacture and VN/SN fields, and these have been used in the interim for temporarily differentiating between certain models.



A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

To enter or edit details in respect to ***Holds***, either click on the appropriate ***Holds*** link on the right hand side of the table, or select that screen from the main screen.

In order to make changes to an existing ***Aircraft***, locate that ***Aircraft*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

In many cases Operators utilise very similar aircraft. A series of ***Templates*** are contained in the list of ***Operators***. It is possible to simply ***Copy*** an existing ***Aircraft*** including the attached ***Hold*** information and rename the "Copy" to a new Operator via the ***Edit*** selection. The example below has been copied from the China Airlines aircraft. A copied line appears at the top of the page. Not that the copy has not been assigned to an operator, it now requires editing.

Administration >> Aircraft

Add and edit aircraft details. Copy an existing aircraft to speed up data entry. Use the Holds link to edit Aircraft Hold details.

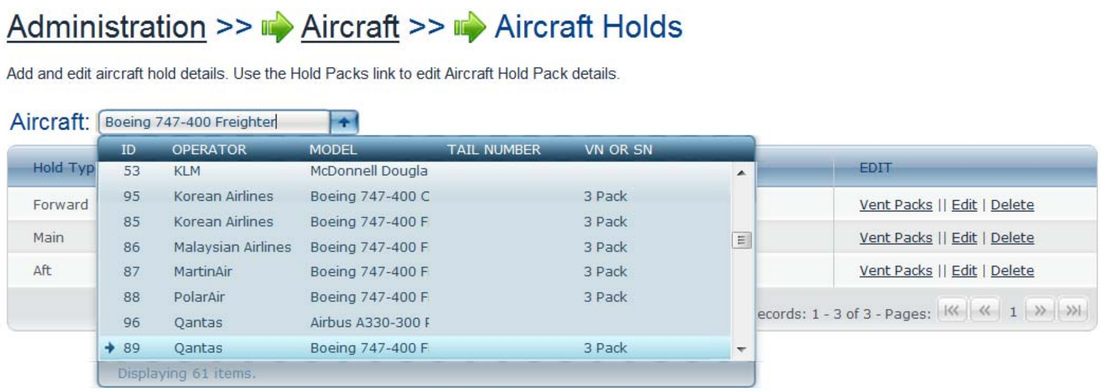
Operator	Model	Year	Tail Fin	VN/SN	EDIT
	Boeing 747-400 Freighter	1999	Copy of	3 Pack	Holds | Copy || Edit | Delete
Air Canada	Airbus A330-200 Freighter	1998			Holds | Copy || Edit | Delete
Air Canada	Airbus A330-300 Passenger	1999			Holds | Copy || Edit | Delete
Atlas Air	Boeing 747-200 Freighter	1999			Holds | Copy || Edit | Delete
Atlas Air	Boeing 747-400 BCF	1980		3 Pack	Holds | Copy || Edit | Delete
Atlas Air	Boeing 747-400 Freighter	1999		3 Pack	Holds | Copy || Edit | Delete
Cargolux	Boeing 747-400 Freighter	1998		3 Pack	Holds | Copy || Edit | Delete
Cathay Pacific	Airbus A330-200 Freighter	1998			Holds | Copy || Edit | Delete
Cathay Pacific	Boeing 747-400 Freighter	1998		3 Pack	Holds | Copy || Edit | Delete
China Airlines	Boeing 747-400 Freighter	1999		3 Pack	Holds | Copy || Edit | Delete

Add New - Show Filter - Records: 1 - 10 of 62 - Pages: 1 2 3 4 5

Aircraft Holds

Enter the ***Aircraft Hold*** page via the hold link on the ***Aircraft*** page or directly from the ***Administration*** page.

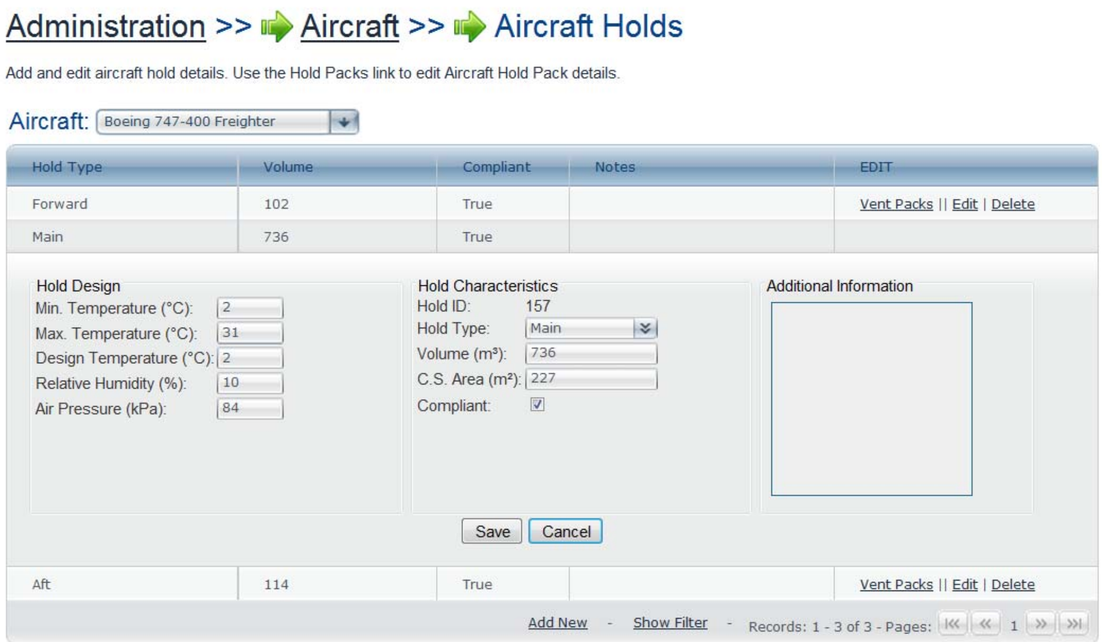
There is a drop down box next to ***Aircraft***. This allows selection of the correct Operators Aircraft. It provides addition detail in case of variants to a generic line of aircraft. Select the appropriate Operator's aircraft.



You can now add a ***Hold***. Aircraft generally have three holds, ***Main***, lower ***Forward*** and lower ***Aft*** but not all holds are required to be entered if they cannot be used for the transport of livestock.

To add a new Aircraft Hold click on ***Add New*** with the ***Aircraft*** page open and enter the following:

- Hold Design Constants which relate to the aircraft operating capabilities (see below). In many cases these can be copies from the same model aircraft of another Operator. However care should be taken to identify variants to the standard design.
- Hold Characteristics including ***Hold Type*** from the dropdown list, ***Volume*** (m^3), the Cargo Storage Area (m^2) and whether the hold is Compliant i.e. it has ventilation and is suitable for the carriage of livestock;
- Any ***Additional Information*** which could relate to limitations or the acceptability of the hold in general; and
- Click on ***Save***.



In order to make changes to an existing ***Aircraft Hold***, locate that ***Aircraft*** and ***Aircraft Hold*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

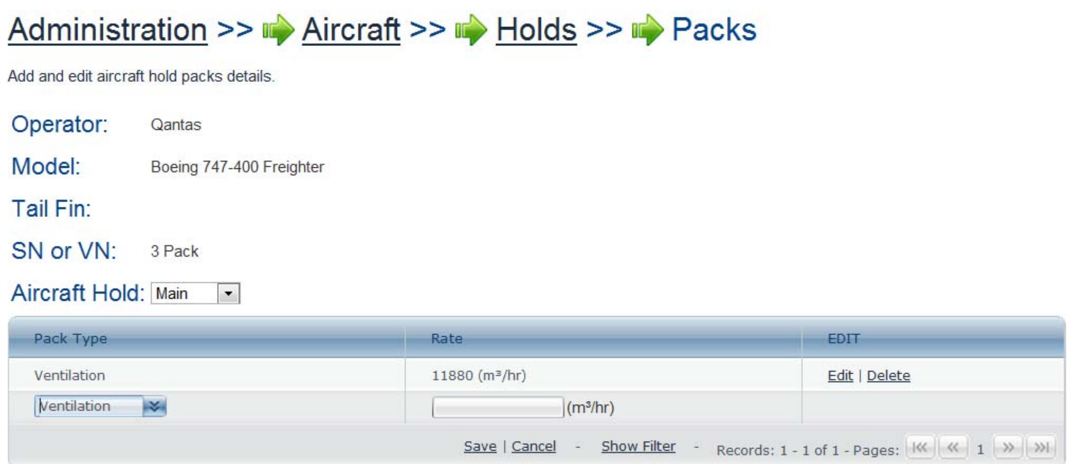
A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Aircraft Hold Packs

Enter the aircraft hold ***Packs*** page via the ***Vent Packs*** link on the **Aircraft Holds** page or directly from the ***Administration*** page.

To add hold ventilation details click on ***Add New*** with the ***Packs*** page open and then enter the following:

- The ***Aircraft Hold*** (select from drop-down list);
- The ***Pack Type*** (select from drop-down list). If ***Recirculation*** is chosen then the ***Hold*** is NOT suitable for the transport of livestock i.e. not ***Compliant;***
- The ***Ventilation*** or ***Recirculation Rate*** (m³/hr); and
- Click on ***Save***



In order to make changes to an existing ***Pack Type***, locate that ***Pack Type*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

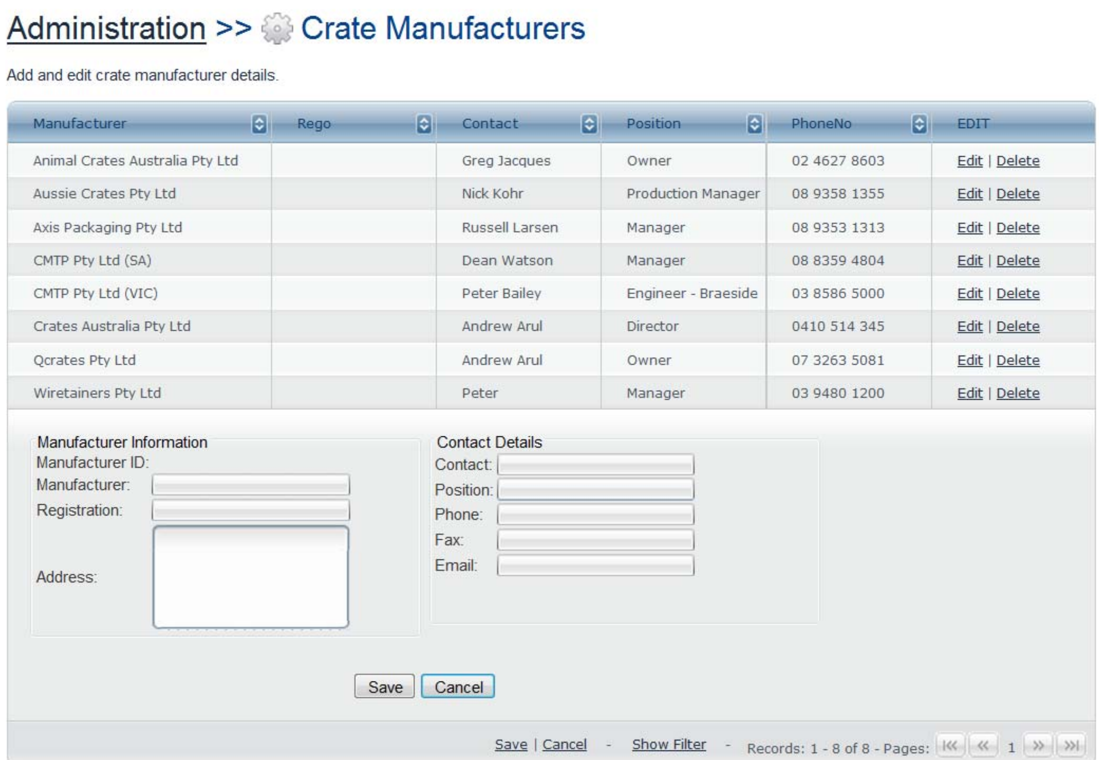
A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Crate Manufacturers

Enter the ***Crate Manufacturers*** page via the ***Administration*** page.

To add a new crates manufacturers click on ***Add New*** with the ***Crate manufacturers*** screen open and enter the following:
The crate manufacturer's name;

- Their Registration number (if any);
- The manufacturer's address;
- The contact person;
- Their position in the organisation;
- Details of their phone, fax and email address; and
- Click on ***Save***.



In order to make changes to an existing ***Crate Manufacturer***, locate that ***Crate Manufacturer*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

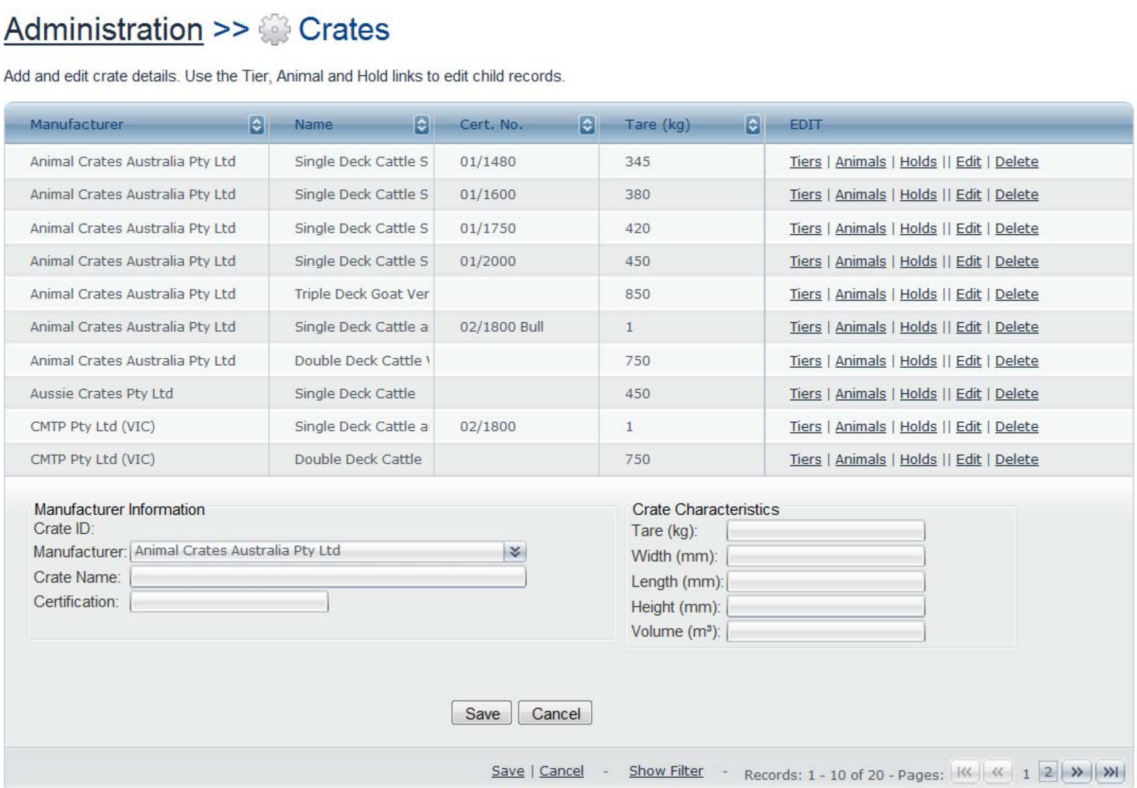
A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Crates

Enter the ***Crate*** page via the ***Administration*** page.

To add a new crates click on ***Add New*** with the ***Crates*** screen open and enter the following:

- The crate manufacturer's name (select from drop-down list);
- The crate name;
- The ***Certification Number*** (if any);
- The crate tare weight(kg);
- The crate dimensions (mm);
- The overall volume (m^3); and
- Click on ***Save***.



In order to make changes to an existing ***Crate***, locate that ***Crate*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line. In order to enter data in respect to ***Tiers***, ***Animals*** or ***Holds***, either click on the appropriate link on the right hand side of the table, or select that screen from the ***Administration*** page.

Crate Tiers

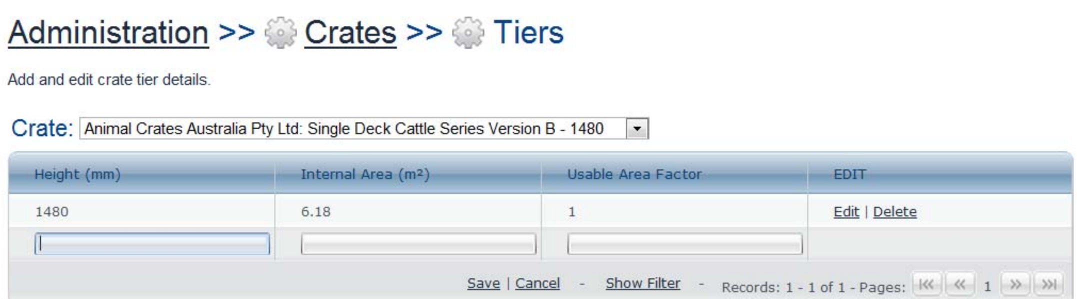
Enter the ***Tiers*** page via the ***Tiers*** link on the ***Crate*** page or directly from the ***Administration*** page.

The details of the internal dimensions of a tier (or tiers with a multi tiered crate) are entered here. With the ***Tiers*** page open and the specific crate displayed in the drop down list above the crate tier table, click on ***Add New*** and proceed to enter the following for each tier (or crate deck):

- The tier height (mm);
- The internal useable floor area (m²) on that tier (note this is not the outer dimensions of the crate, but the area between the innermost structural components);
- A value for the usability of the floor area on that tier; and
- Click on ***Update***

You will need to add a new line for each tier in a crate.

One (1) is the normal or default value for ***usable area factor***. Where the profile of the upper tiers is shaped to follow the contour of the aircraft hold, the useable floor area available under the ASEL standards may be less than 1 (e.g. 0.8 if 20% of the floor area is not effectively available to the transported stock due to restricted headroom). This default may not be utilised in practice as the User has access to an ASEL Reduction function in that section of the Website.



In order to make changes to an existing ***Tier***, locate that ***Tier*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Crate Animals

Enter the ***Animals*** page via the ***Animals*** link on the ***Crate*** page or directly from the ***Administration*** page.

Crates might only be suitable for transporting certain types of animals. To add a new animal types, with the ***crates and animals*** screen open and the specific crate displayed in the drop down list above the crate holds table, click on ***Add New*** and enter the following:

- The animal type (select from the drop down list); and
- Click on ***Save***.

In order to make changes to an existing ***Animal***, locate that ***Animal*** in the list. Click on ***Edit*** to change the details. Click on ***Update*** when finished.

A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

Crate Holds

Enter the ***Crates and Aircraft Holds*** page via the ***Holds*** link on the ***Crate*** page or directly from the ***Administration*** page.

The program uses the information stored in this table to determine an estimate of the space used in a particular hold based on the maximum number of crates that can fit in a hold. This maximum number may be limited by floor space or by ventilation operational characteristics.. If a crate is chosen by a User that has not been assigned to the nominated aircraft and hold the program will present an error. That error will occur even if zero (0) is listed as the maximum number of crates that can be assigned to a particular aircraft hold.

To add a ***new Crate-Aircraft Model combination***, with the ***Crates and Aircraft Holds*** screen open and the specific crate displayed in the drop down list above the crate holds table, click on ***Add New*** and enter the following:

- The aircraft model (select from drop-down list);
- The hold type (select from drop-down list);
- Enter the maximum number of crates of that type that will normally fit in the specified hold of an aircraft (information generally available from manufacturers); and
- Click on ***Save***.

Some carriers may specify that livestock cannot be carried at certain positions in certain holds. Similarly, some carriers may have aircraft with non-standard hold configurations that might allow additional crates to be carried. Hence the nominated 'maximum' shown here should be treated as indicative only.

Administration >> Crates >> Crates and Aircraft Holds

Add and edit crate, aircraft model and hold combination details.

Crate: Animal Crates Australia Pty Ltd: Single Deck Cattle Series Version B - 1750

Aircraft Model	Hold Type	Max Crates	EDIT
Boeing 747-400 BCF	Main	30	Edit | Delete
Boeing 747-400 Freighter	Main	30	Edit | Delete
Boeing 767-200 Cargo	Main	1	Edit | Delete
Boeing 767-300 Cargo	Main	1	Edit | Delete
Boeing 767-300 GMF Series	Main	1	Edit | Delete
Boeing 777-200 Cargo	Main	1	Edit | Delete
Boeing 777-300 Cargo	Main	1	Edit | Delete
McDonnell Douglas MD11 Freighter	Main	1	Edit | Delete
Airbus A330-200 Freighte	Main		

Save | Cancel - Show Filter - Records: 1 - 8 of 8 - Pages: 1

In order to make changes to an existing ***Crate and Aircraft Hold***, locate that ***Crate and Aircraft Hold*** in the list. Click on ***Edit*** to change the details. Click on

Update when finished.

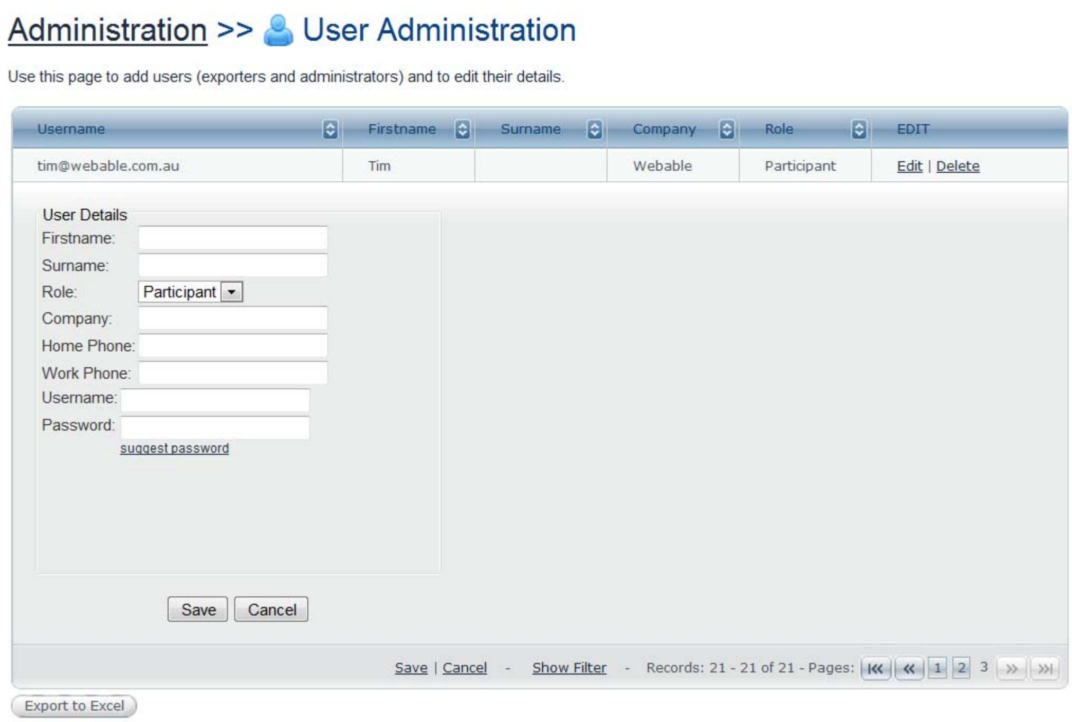
A line item may be deleted by selecting the ***Delete*** function on the appropriate line.

User Administration

Enter the ***User Administration*** page via the ***Administration*** page.

To add a new user click on ***Add New*** with the ***User Administration*** screen open and enter the following:
The user's first name;

- The user's surname;
- The user's role in respect to LATSA (i.e. Participant or Administrator);
- The user's company or trading name;
- Contact phone numbers;
- The user's designated username (an email address);
- The user's designated password; and
- Click on ***Save***.



The program will attempt to notify the User of their access status via email. If email is functioning correctly a default email will be sent immediately upon clicking save. If changes are made to the user a second email will be sent to the user advising the changes. Emails will only be received if the email system is operating correctly on the installed server.

Once a ***User*** has been entered, click on ***Edit*** to change details. Click on ***Save*** when finished.

Access to various tables is conditional on the type of user - either ***Administrator*** or ***Participant***. A user who is assigned as an ***Administrator*** cannot access the program as a ***Participant*** and vice versa. If an ***Administrator*** is also a ***Participant*** or "Export User" then that person will require two different ***Usernames***. The ***User Administration*** details may be exported to Excel via the control button at the bottom of the page. This list can be saved locally.

9.9 Appendix 9 – LATSA V2.0 Users Manual

LATSA Version 2.0 - Participant Manual

Table of Contents

Introduction

LATSA Version 2.0 is a tool intended to allow livestock exporters who consign cattle, sheep, goats and camelids on aircraft flights out of Australia to:

- Plan and design their consignments to comply with ASEL standards;
- Check the spatial and weight limitations of the crates they intend to use; and,
- Assess the general adequacy of the aircraft heating, ventilation and air conditioning (HVAC) system in respect to heat, moisture and carbon dioxide likely to be emitted by the animals while in transit.

LATSA is a Web based program which consists of:

- A set of Structured Query Language (SQL) data tables;
- An operating program;
- A Web interface which currently resides on one of the LiveCorp servers; and,
- ***Participant*** and ***Administrator*** log in options.

This user manual is for ***Participant*** users. As a ***Participant*** in this system you will only be aware of the data you store regarding your own consignments and the results and documentation associated with them. All data entered by ***Participants*** is confidential and password protected.

What's New

LATSA Version 1.0 provided users with a tool to assess whether it was safe to carry specific groups of livestock on specified operators planes. It was designed in line with various air industry standards but limited users to fixed load choices. Livestock consignments are unfortunately mixed and varied and the fixed weight groupings did not allow the user enough flexibility. In addition the software required user intervention in order to update data tables.

As a result of the various limitations, an upgrade was implemented. The objectives of the new program LATSA Version 2.0 were to provide the following improvements:

- Access to a live database via an Internet based interface;
- Ability to evaluate consignments of all weights for cattle, sheep, goats and camelids;
- Ability to calculate stocking densities based on ASEL standards for consignments of multiple species and varying liveweights;
- Ability to calculate the gross and net payload required to fit a desired consignment to ASEL standards;
- Inclusion of an accessible database of registered crate manufacturers and certified stock crate designs;
- If aircraft ventilation is not sufficient to cope with the initial consignment proposal, the software has the ability to modify consignment details and recalculate stocking densities and other factors to ensure adequate ventilation for livestock; and,
- Save consignment documentation to your local PC for printing and submission to AQIS.

The above objectives have been incorporated into the new version. This version is accessible in two ways, either as an ***Administrator*** or as a ***Participant***.

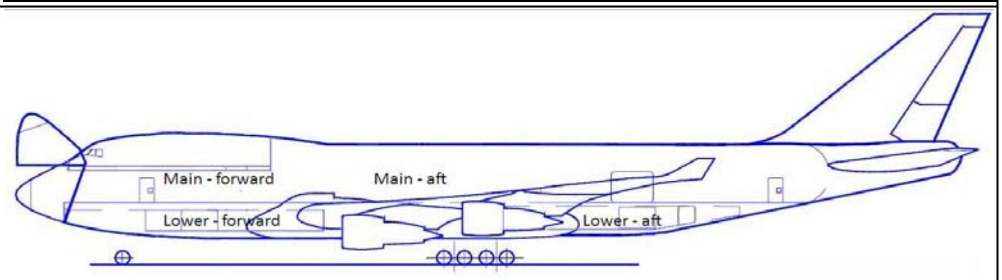
The ***Administrator*** area is not accessible to ***Participants*** and contains animal, crate and aircraft data which remain constant throughout the numerous calculations undertaken behind the scenes.

You will note that some words in this manual are in ***BOLD ITALIC.*** This indicates that the word has a specific meaning, position or operation within LASTA 2.0.

LATSA V2.0 has a time out function to protect you and your data. If you are logged in and leave your computer idle for more than 20 minutes the program will assume you have completed your session and log you out. Your data is generally saved unless you have not completed all the required detail in the particular window you were accessing. If the screen hangs and does not return to the ***Login*** page on recommencing your session, it is recommended that you refresh your screen and force the system to reset itself back to the ***Login*** page.

Definitions of Terms Used in LATSA V2.0

Term	Definition
UCT	Upper critical temperature (°C) - The upper limit of an animal's thermo-neutral temperature range. Above this temperature an animal will need to expend energy to cool itself. This is commonly seen as the animal beginning to pant. If the ambient temperature exceeds the UCT for a prolonged time or is substantial, the animal will suffer heat stress. Where a mix of different animal species or types are in a consignment, the UCT that LATSA provides for that consignment will be the lowest of the UCT values for the individual lines of stock in that loadline or consignment.
LCT	Lower critical temperature (°C) - The lower limit of an animal's thermo-neutral temperature range. Below this temperature an animal will need to expend energy to keep warm. This may involve increasing metabolic activity, and perhaps the onset of shivering. If the ambient temperature is below the LCT for a prolonged time or the temperature differential is substantial, the animal may suffer cold stress. Where a mix of different animal species or types are in a consignment, the LCT that LATSA provides for that consignment will be the highest of the LCT values for the individual lines of stock in that loadline or consignment.
Hold exit temperature	The estimated temperature of the air vented from the hold (°C). This represents an estimate of the highest temperature any animals in that hold might be exposed to, assuming uniform mixing and no stratification of air within the hold. As it is the exit temperature, the average temperature within the hold is likely to be between the inlet and the exit temperature (i.e. the exit temperature is generally the 'worst case' for that consignment, so providing a conservative estimate of the conditions in the specific hold).
THI	Temperature Humidity Index - A generic (but not definitive) measure of likely animal comfort based on ambient temperature and humidity levels.
Hold	The hold names applied in LATSA are shown below. These are: • ***Main***; • Lower ***Forward***; and • Lower ***Aft***.

Term	Definition
	 While the HVAC system may provide different zones in some holds (refer Main - forward and Main - aft in the B747 above), this version of LATSA only considers the individual holds each as a single environment.
Tiers	The floors in each deck of a livestock crate (i.e. a 2-tier crate will have two 'decks').
Stocking density (calculated)	Stocking density is considered here to be the total useable floor or deck space available to the animals being transported on each deck, expressed on a *per capita* or per animal basis (*i.e*. expressed in units of m^2/head). The useable area applied in version 2 of LATSA is derived from the internal dimensions of the crate (*i.e*. the minimum horizontal distances between the opposite, innermost members of the vertical sides or ends of the crate on each deck)
ASEL stocking density	The maximum allowable stocking density for that species and liveweight of animal, as provided in the ASEL standards (Australian Standards for the Export of Livestock).

Getting Started

LATSA Version 2.0 is a secure system managed by a designated ***Administrator***. Access to your data is via your ***Username*** and ***Password***. Your information is secure from other ***Participants*** of the system. An ***Administrator*** cannot access the ***Participants*** area under their ***Username*** and ***Password***, The ***Administrator*** can access your data but only by changing your ***Password*** and logging in with your ***Username***.

An ***Administrator*** has access to the following areas:

- To setup ***New Participants*** and modify the setup of existing ***Participants*** when changes are requested;
- To change values of constants used in calculations throughout the program; and,
- To add and edit data such as ***Airports, Aircraft Operators, Aircraft Models, Aircraft Details, Crate Manufacturers*** and ***Crate Designs***.

A ***Participant*** has access to the following areas:

- Setting up and editing ***Consignments***
- Viewing and saving ***Consignment*** documentation

As you read on you will learn how to access the system as a ***Participant***, load and edit data, review your ***Consignment*** then access your information in printed form.

System Requirements

LATSA Version 2.0 is web-based software requiring the following:

- A compliant Operating System - The program has been tested successfully with Windows 2000, Windows XP, Windows Vista, Windows 7, Mac OS X;
- Internet access and an Internet browser;
- An email system to receive documents sent from the program, and,
- Access to a printer when printing any documents.

As there is no software to load it is a simple system to operate. This version of LATSA does not provide access to your stored data other than through on-screen viewing and the provision of documentation through a local save or print.

Getting Help

Due to its relative simplicity LATSA does not include any context sensitive help. The help information provided here is available as a Windows Help file (.chm format), as well as in HTML format (accessible using a web browser or Microsoft Word) and PDF format (accessible using Adobe Acrobat Reader). These files are generally provided by the ***Administrator*** with your registration on the system.

You may find that the selections you want to use within the program are missing. For instance you may want to use a particular ***Hold*** in an ***Aircraft*** owned by a certain ***Carrier*** and it is not available or you may wish to use a ***Crate*** that is not listed for a particular ***Hold*** of an ***Aircraft***. If this occurs you should contact the Administrator for assistance. If the selection you are looking for is already approved, the selection can be quickly addressed by the ***Administrator***. If the selection is new it may have to be validated and approved before use. Please ensure you provide as much detail as possible to the ***Administrator***.

The system is currently being administered by Luke Hogan of EnviroAg Australia Pty Ltd. If you need assistance please call or contact one of the following:

Luke Hogan	luke.hogan@enviroag.net.au	(07) 4676 8283 or (0434) 420 785
David Beatty	dbeatty@mla.com.au	(02) 9463 9385
LiveCorp	dstarr@livecorp.com.au	
LiveAir	chair@liveair.org.au	

Log On

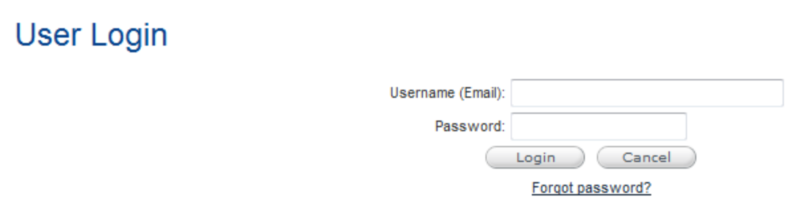
LATSA Version 2.0 can be accessed via the following URL:

http://www.livecorp.info/Login.aspx

We recommend that you save this website to your "Favourites" and/or set up a shortcut on your desktop.

When you enter this website you will see the following Log In screen.

You may either click on login in the descriptive sentence of this page or click on LOGIN in the top right of the screen. The following page will appear.



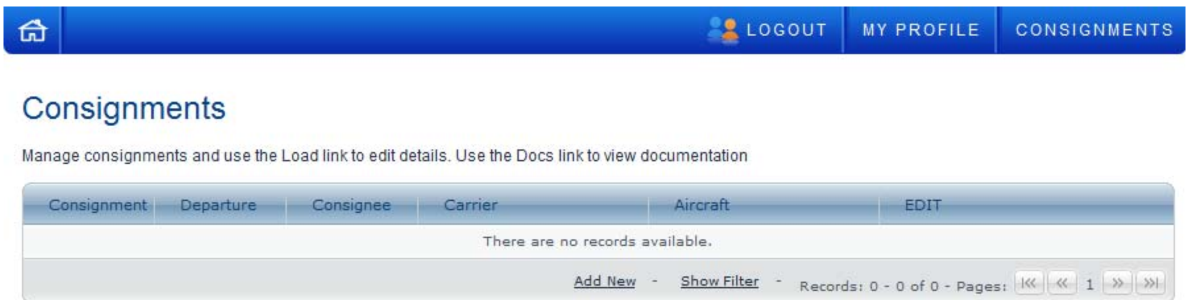
To access your data on the website:

- Enter your assigned ***Username*** which will generally be your preferred email address;
- Tab or click on the ***Password*** field and enter your assigned ***Password;*** and
- Click on ***Login*** button

The ***Forgot password?*** function has not been activated in this version of LATSA. If you have forgotten your password you should contact the ***Administrator***. When login has been successful you will see the ***Consignments*** page.

Consignment Screen

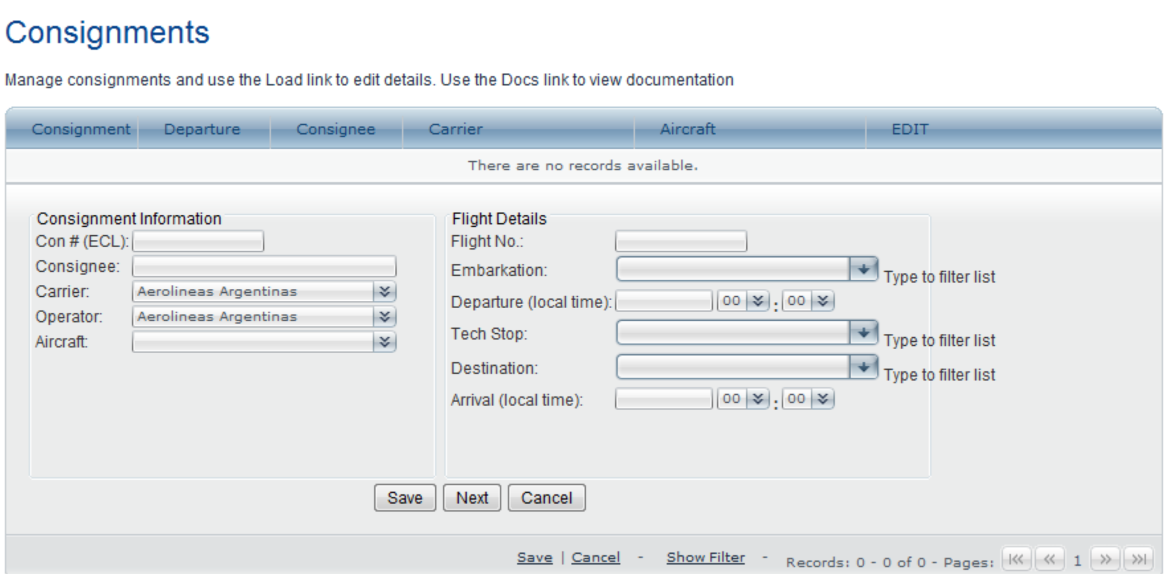
On opening, LATSA displays the ***Consignments*** page. This will initially be as below. Once you have entered a consignment, it will then be listed here, and you can return to this screen to edit any consignment, delete it or make other changes.



Click on ***Add New*** to start entering your first consignment.

Add a New Consignment

Having clicked on ***Add New*** the following page will appear.



This is the setup screen for a new consignment. You may enter details about your consignment here and alter them later if your data is either not correct or incomplete at the time of initial entry. In particular you may need to change planes, flights and times once the consignment has been confirmed. It may be necessary to enter "dummy" information in some fields for which you don't yet have appropriate data.

The field ***Con # (ECL)*** is your personal load or consignment identification. This equates to the first column of the ***Consignments*** opening page. ***Consignments*** will appear in numeric then alpha character order based on your tracking methodology.

The ***Consignee*** field is also useful for searching consignments. This field appears on documents referred to later in this manual. The name of the ***Consignee*** should match that used in the "Notice of Intention to Export" presented to AQIS in preparation for shipment approval.

Both a ***Carrier*** and ***Operator*** have been included due to the issue of subcontracted air transport. For instance you may book your flight through Qantas as the ***Carrier*** but they contract the freight to Atlas Air as the aircraft ***Operator***. The ***Aircraft*** selection is only linked to the ***Operator***. Generally all ***Aircraft*** owned by the ***Operator*** (that are compliant for the carriage of Livestock) will be listed in the **Aircraft** drop down box.

The ***Aircraft*** selections available to the ***Participant*** are controlled by the ***Administrator***. Please contact the ***Administrator*** if your desired selection is not available, if it is new it may need validation and approval before it can be made available.

Enter your flight number then select your ***Embarkation*** port from a pre-filtered list of Australian and New Zealand ports. The ports are listed by name and not IATA code. You can start typing and a handy automatic filter will limit your available selections according to the letters you have typed. The ***Departure*** date can be selected from a popup calendar once you click on the vacant field. The time must be selected from the drop down ***Hour*** and ***Minute*** lists.

The ***Tech Stop*** list contains all available ports and like the ***Embarkation*** field, has a character filter to limit your selections. The ***Destination*** field filters entries in exactly the same manner. ***Arrival*** dates and times are entered as above. You must enter the local arrival time as the program accounts for GMT differences automatically in its flight time calculation. For simplicity this calculation currently ignores daylight saving.

You may ***Save*** your entry then continue to make changes. Alternatively you can click the ***Next*** button. Doing the latter will save your entry and progress you to the ***Loadlines*** page where you can commence entering your load details.

Load a Consignment

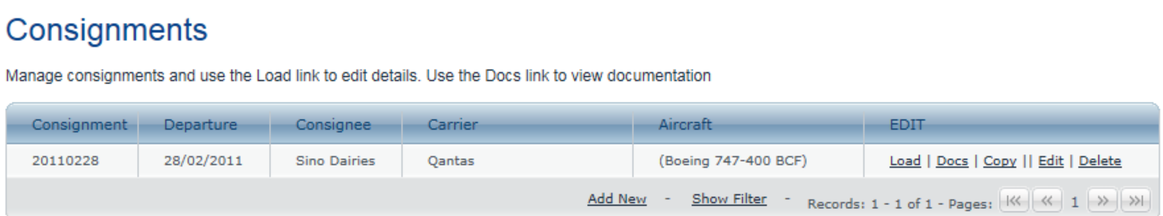
Once you have entered your basic ***Consignment*** details you are ready to build your load. The details of the animals you are shipping are entered as ***Loadlines***.

Loadlines in LATSA are defined as groups (or lines) of the same stock and liveweight loaded into the same crate and placed into the same hold of an aircraft. Multiple lines of stock can be entered in any of the available holds in an aircraft (e.g. separate lines of sheep and goats in one hold, separate lines of 250 kg and 350 kg cattle in another hold). If however the same type of stock are to be carried in different holds (e.g. 180 yearling cattle in the main hold and 15 yearling cattle in the forward lower hold), these need to be entered as separate ***Loadlines***. You may even need to use two different ***Crates*** and therefore two ***Loadlines*** in the same hold for the same species and average liveweight of stock. This may occur where the ***Carrier*** or ***Operator*** specifies a maximum number of three tier ***Crates*** and the balance as two tier ***Crates*** for the carriage of goats so as to ensure effective air distribution.

In practice you may also load different average liveweights into different Decks (Tiers) of multi-tiered Crates. LATSA in its current form is not designed to deal with this. It is recommended that you attempt to fill each ***Crate*** (and as a result each ***Loadline***) with the same species and average liveweight and use another ***Loadline*** for the change in average liveweight. An alternate strategy is to recalculate the average liveweight of all same species stock (loaded into the one crate type and use this new weight and total head in you ***Loadline***. This latter approach can obscure the issues relating to ASEL stocking density and may need careful consideration before proceeding. It will also affect the presentation of your final documentation.

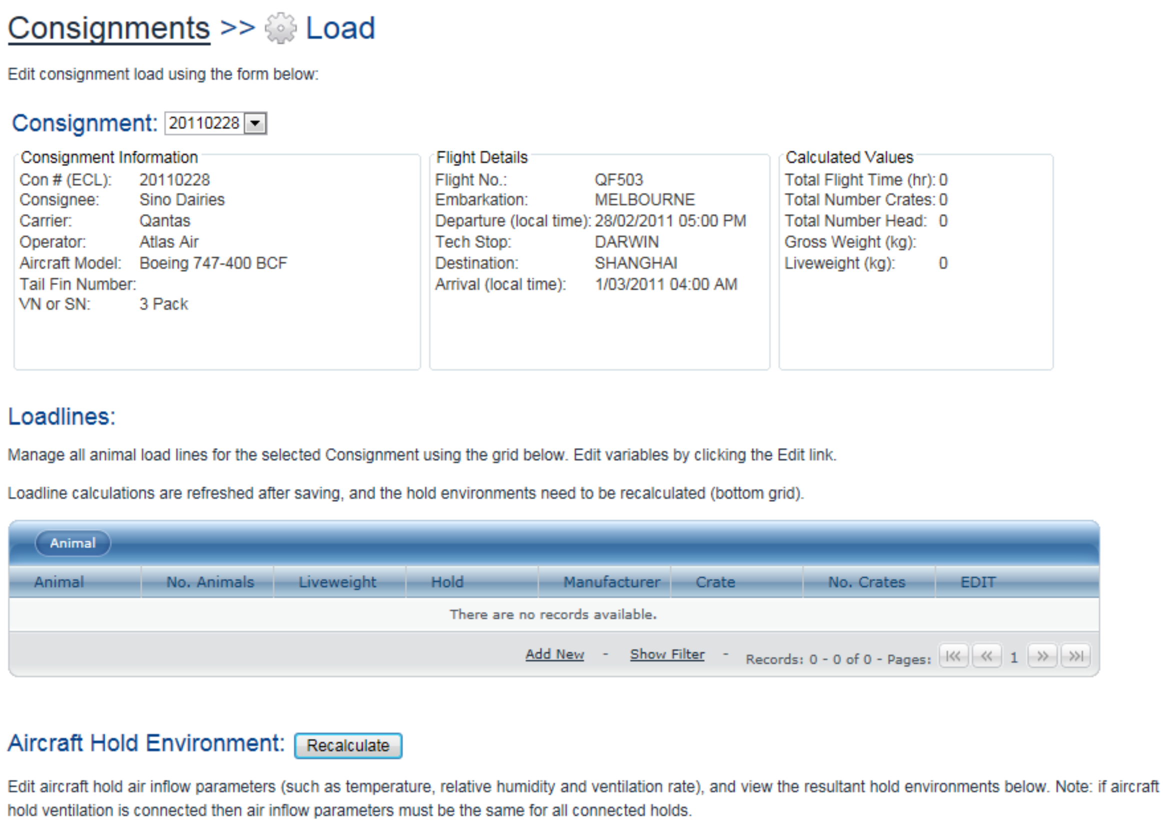
You can access the ***Loadlines*** page by two means:

- By Clicking the ***Next*** button at the completion of ***Add New*** in the detail of a ***Consignment***; or,
- By clicking ***Load*** on the main ***Consignments*** page show below.



Consignment	Departure	Consignee	Carrier	Aircraft	EDIT
20110228	28/02/2011	Sino Dairies	Qantas	(Boeing 747-400 BCF)	Load | Docs | Copy || Edit | Delete

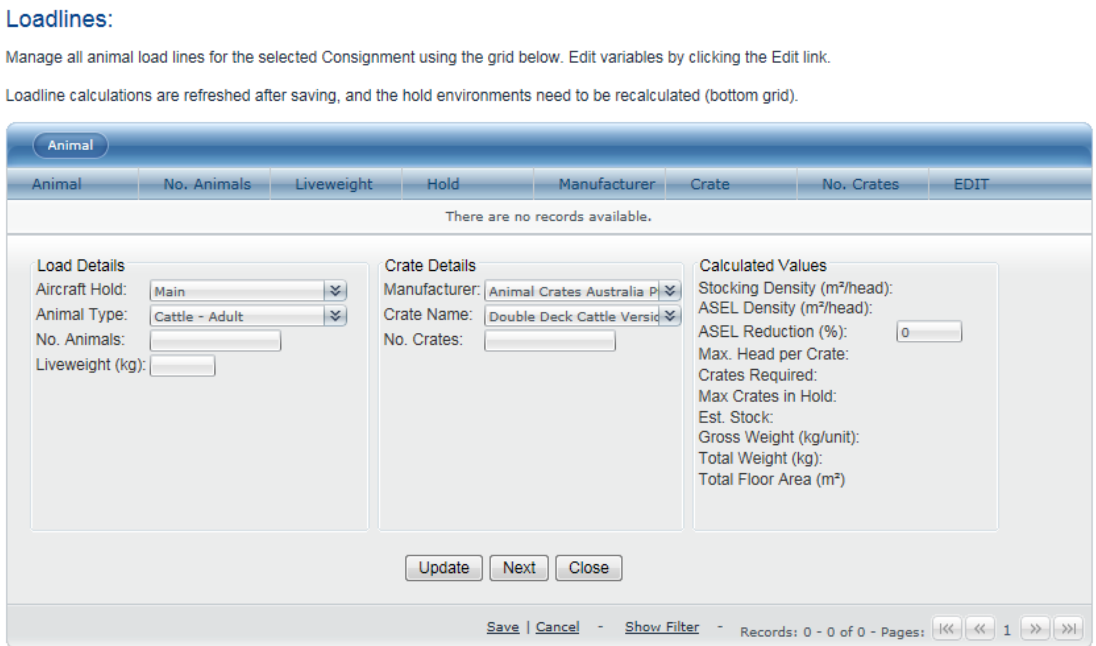
Having clicked on ***Next*** or ***Load***, the ***Load*** detail page appears as follows:



You will note that it is broken up into three sections:

- ***Consignment*** details which you entered previously;
- ***Loadlines*** where you enter new Loadline details or modify existing lines; and
- ***Aircraft Hold Environment*** details which will be calculated only after you have entered at least one ***Loadline***.

At this point you should click on ***Add new*** below the ***Loadlines*** summary to open the ***Loadlines*** detail window. This will allow you to access the detail for a new ***Loadline***.



Once you are here you can enter two classes of information for ***Load*** and ***Crates*** then investigate the density and crate results and recommendations.

Load Details

- Nominate the ***Hold*** from the drop down list that the line of stock is to be carried in (if the hold is listed for that ***Aircraft*** by the ***Administrator*** it will be available for selection);
- Select the species and age category (***Animal Type***) of the animal being transported from the drop down list. Adult or young stock need to be specified as physiological parameters differ and influence the software calculations;
- Nominate the number of animals in that line of stock;
- Enter the average ***Liveweight*** of that line of stock.

Crate Details

- Select the ***Manufacturer*** of the crate being used from the drop down list;
- Select the model of crate from the list of ***Crate Names*** available for that ***Manufacturer*** (you are able to select any ***Crate*** from that ***Manufacturer*** so some knowledge of what can fit in your Hold selection is useful but not essential);
- Nominate the proposed number of crates (this may need to be revised later);

When you have finished entering the data, click on ***Update***. This will then populate the ***Calculated Values*** table on the right of the ***Loadlines*** window. The following information will be displayed:

- The ***Stocking Density*** of the proposed line which will display green if the value is acceptable under the ASEL standards, and red if not;
- The ***ASEL Density*** for that animal at the nominated liveweight;
- An ***ASEL Reduction*** which can be altered to increase the space allowed per animal (ASEL may specify that the animals must have 10% more space for several reasons);

- The ***Maximum*** number of ***Head per Crate*** to comply with the ASEL Stocking Density;
- The minimum number of ***Crates Required*** based on the ASEL Density and the number of animals nominated in the ***Load Details***;
- The ***Maximum*** number of ***Crates in*** the ***Hold*** (this will indicate a maximum number which should not generally be exceeded or will be zero (0);
- The value presented as the ***Est. Stock*** is a guide to how many head of animals should fit in the nominated number of ***Crates*** based on the ***ASEL Density*** for that ***Liveweight***;
- The ***Gross Weight*** is the combined weight of a single ***Crate*** and its nominated load;
- The ***Total Weight*** is the combined weight of all ***Crates*** and their nominated loads; and,
- The ***Total Floor Area*** is based on the nominated number of Crates and the Crate's nominated external dimensions.

Several considerations may be required at this point and the ***Calculated Values*** can assist you.

If your ***Stocking Density*** is appearing in red this means you have nominated too may livestock for the number of Crates entered in comparison to the defined ASEL allowance. You can reduce the number of livestock to the value at ***Est. Stock*** or you can increase the number of crates to the value at ***Crates Required*** provided that this does not exceed the value at ***Max Crates in Hold***.

If the result at ***Max Crates in Hold*** is zero (0), it means that the selected ***Crate*** has not been assigned to this ***Aircraft*** and ***Hold*** by the ***Administrator***. You should choose a more appropriate ***Crate*** or seek advice from the ***Administrator.*** At this stage you are not restricted from selecting any ***Crate*** you simply need to be aware that the ***Space Used*** result will also appear as zero (0) if the Crate has not yet been assigned to the ***Aircraft*** and ***Hold*** combination.

If you are forced to apply an ASEL Reduction of say 10% this will simply reduce the allowable ***ASEL Density*** value used in comparison with your actual ***Stocking Density.*** This will in turn, reduce the number of stock you can carry in the ***Loadline***.

When calculating the ***Max Head per Crate*** in comparison to ASEL Density the result is rounded as per the ASEL standard. Due to this rounding issue, there are cases where the Stocking Density result may be lower than the ASEL Density result but still appear as green.

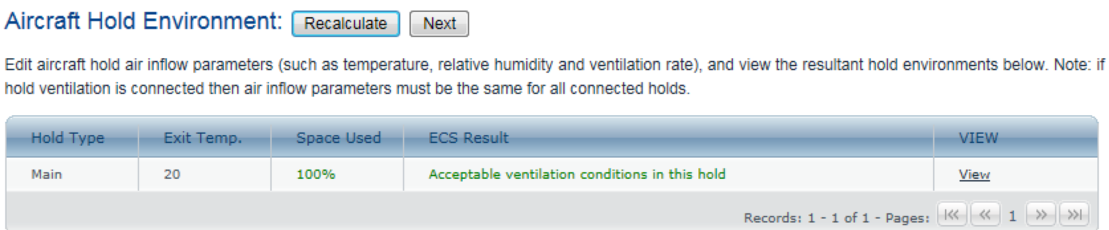
The result at ***Total Weight*** is simply the gross weight of this ***Loadline***. If you wish to check the value of ***Liveweight*** and ***Gross Weight*** for the whole ***Consignment*** you need to update your settings and review the ***Calculated Values*** for the whole ***Consignment*** in the top right of the ***Load*** page.

Following any changes, click on ***Update*** again to recalculate the ***Calculated Values***. Once the ***Loadline*** appears satisfactory, click on ***Next.*** LATSA will then generate and populate the ***Aircraft Hold Environment*** table at the bottom of the ***Load*** page.

Aircraft Hold Environment

Once you are satisfied with your ***Loadlines*** or while even while you are still deciding on the ***Load*** details, you can examine the ***Aircraft Hold Environment*** to check that you are not overloading the ***Aircraft*** ventilation system. To do this click on ***Aircraft Hold Environment*** and ***Recalculate***

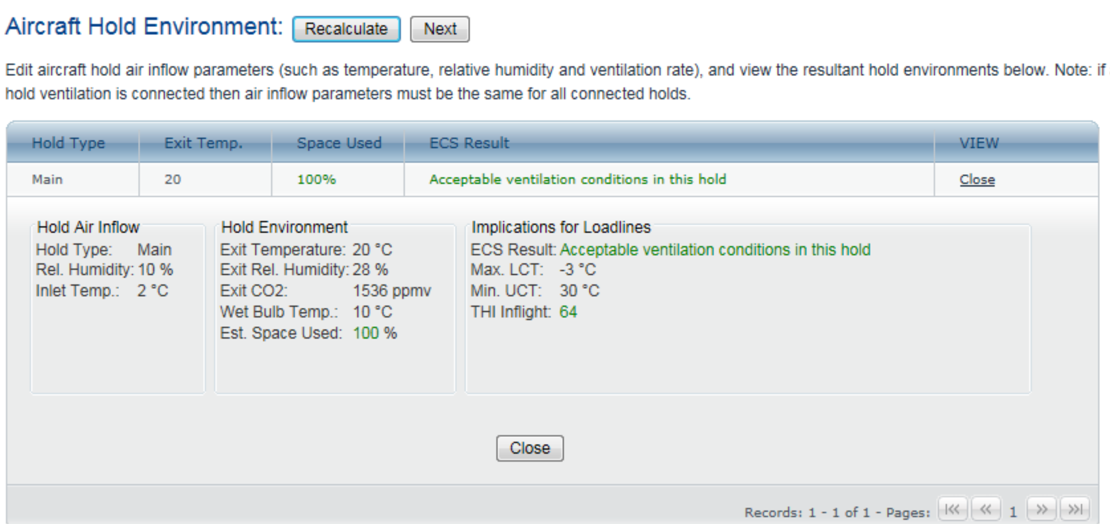
Through a series of physiological and environmental calculations, the data entered in any one of the ***Loadlines*** may result in erroneous information for a ***Hold*** in the ***Aircraft Hold Environment*** table. In several cases, particularly in relation to excessive ***Stocking Density***, it will halt the calculation of environmental data and advise you of necessary changes. This is a safe guard which forces the ***Participant*** to modify input data such as the total number of stock in a hold or the number of crates to be used before moving on. This only applies to the ***Hold*** where the results are outside acceptable limits. Other ***Holds*** in use and loaded correctly may provide adequate results.



This table allows you to check that the following are satisfactory:

- Hold ***Exit Temperature***;
- ***Space Used***; and,
- The Environmental Control System (***ECS***) ***Result***.

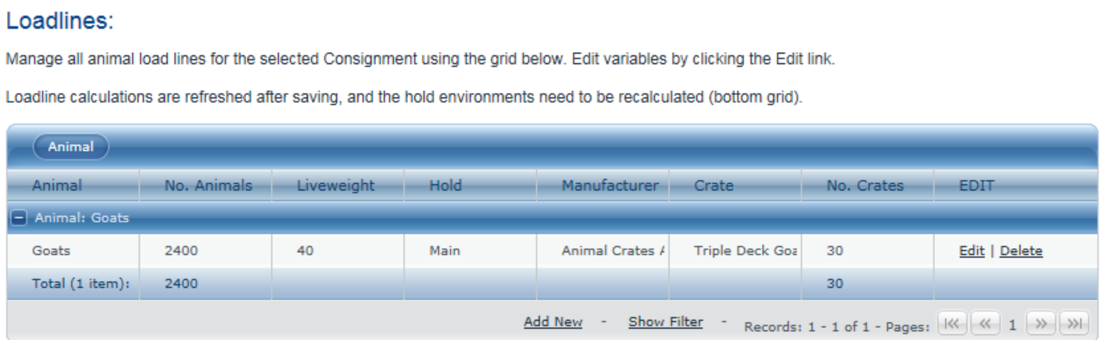
Clicking on ***View*** in a selected ***Hold*** in the ***Aircraft Hold Environment*** table will allow you to see more details. In the event there is a problem with your ***ECS result*** it can indicate what is going wrong with your load.

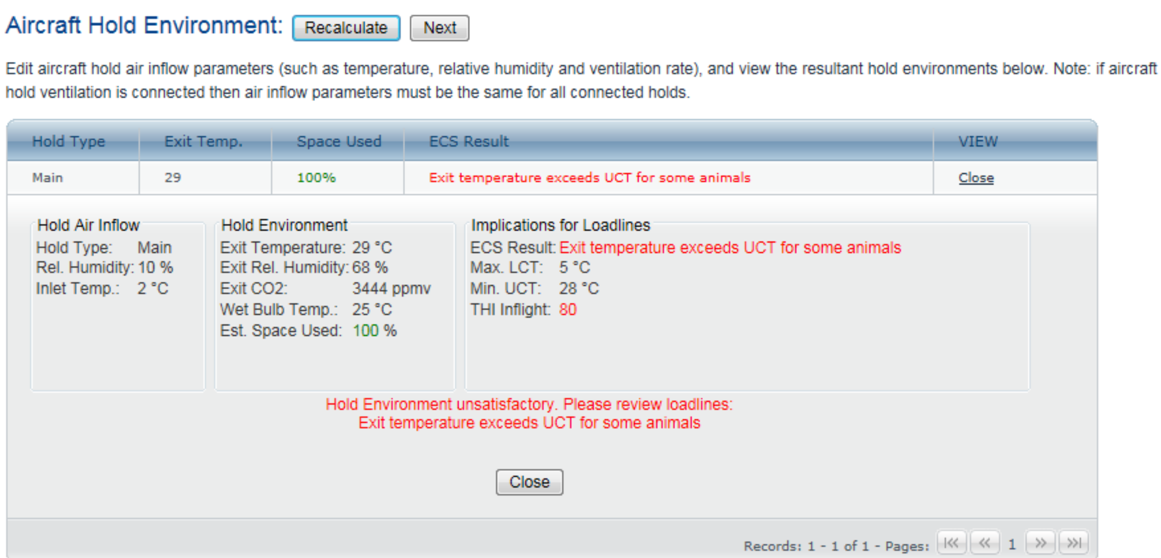


This screen details the Hold Air Inflow conditions used in the calculation of the parameters.

These have been set at the lower limit of the ***Aircraft***'s capability by the ***Administrator***. The ***Hold Environment*** results allow the ***Participant*** to see what the program predicts as the ***Exit*** parameters for the ***Hold*** under the specified ***Load*** conditions. The Implications for Loadlines clearly indicates the ***ECS Result*** together with the ***THI Inflight*** result. Green is an acceptable result while red will indicate some excess of Temperature, Humidity or CO_2.

The following scenario may not be possible due to ***Aircraft*** limitations on weight and the number of three tier crates but is a good example of an excess result.





This ***ECS Result*** indicates that the ventilation system is unlikely to manage the temperature effectively for this ***Load***. The poor result comes about because the ***Exit Temperature*** of 29^0C exceeds the ***Min UCT*** for Adult Goats of 28^0C. It should be noted that ***Exit Temperature*** is the maximum temperature of the ***Hold*** at the exit point of the air system. It is only an indicator as the average temperature may be much lower. However, you can assume that some Goats may be experiencing higher temperature inside crates that have restricted airflow. You will notice that the ***THI Inflight*** is excessive as a result of both elevated ***Exit Temperature*** and ***Exit Humidity***. Together all these results indicate that problems may occur with this ***Load*** and changes are required.

In order to correct most issues with a ***Hold*** result you must edit the ***Loadline*** details for that

Hold. This will generally involve a reduction in the number of stock together with a related reduction in the number or style of Crates. In the particular case above, the selection of 30 triple deck goat crates has purposefully overloaded the flight. In practice the maximum number of this type of crate in the main hold is limited to 15-17 due to airflow restrictions. The remaining crates would be double deck therefore limiting the space available and therefore the total number of stock able to be carried. The secondary crate type would require its own ***Loadline***.

Note that you can ***Load*** several ***Loadlines*** into one ***Hold*** and the system will return a combined ***ECS Result*** for the ***Hold***. This is designed to simplify the system to only a few considerations on the part of the ***Participant***.

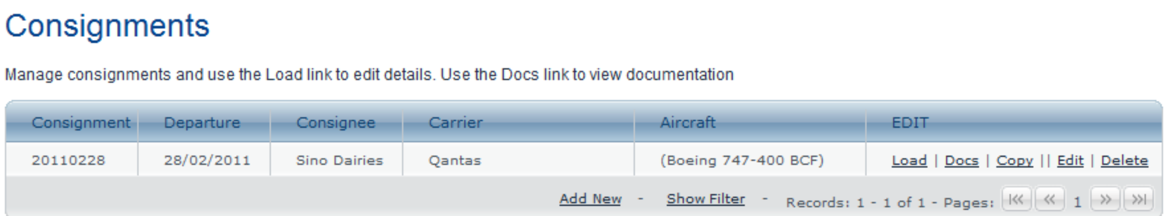
Once you are satisfied with all your ***Loadlines*** generate acceptable ***ECS Results*** you can return to the ***Consignments*** page or click ***Next*** to move on to the Documents page.

Copy a Consignment

A ***Copy Consignment*** function has been included at the request of ***Participants***. This function is useful for two reasons:

- It provides a simple tool to copy common ***Loads*** so that they can be used for similar ***Consignments*** to the same ***Consignee*** or another party; and,
- It allows a ***Participant*** to duplicate the ***Load*** for a ***Transhipment*** (see ***Transhipments***).

The ***Copy*** function is located in the ***EDIT*** column of each ***Consignment*** line of the ***Consignments*** page below.

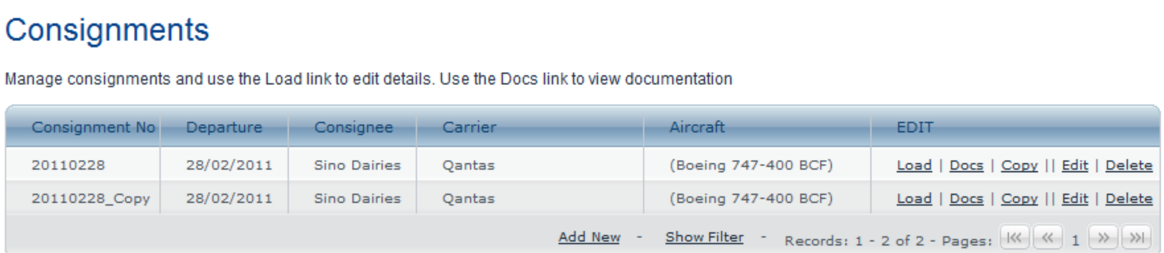

Consignments

Manage consignments and use the Load link to edit details. Use the Docs link to view documentation

Consignment	Departure	Consignee	Carrier	Aircraft	EDIT
20110228	28/02/2011	Sino Dairies	Qantas	(Boeing 747-400 BCF)	Load | Docs | Copy || Edit | Delete

Add New - Show Filter - Records: 1 - 1 of 1 - Pages: 1

Once you have copied the Consignment you will notice that it places a duplicate line at the bottom of you consignment entitled "your selected consignment_Copy".


Consignments

Manage consignments and use the Load link to edit details. Use the Docs link to view documentation

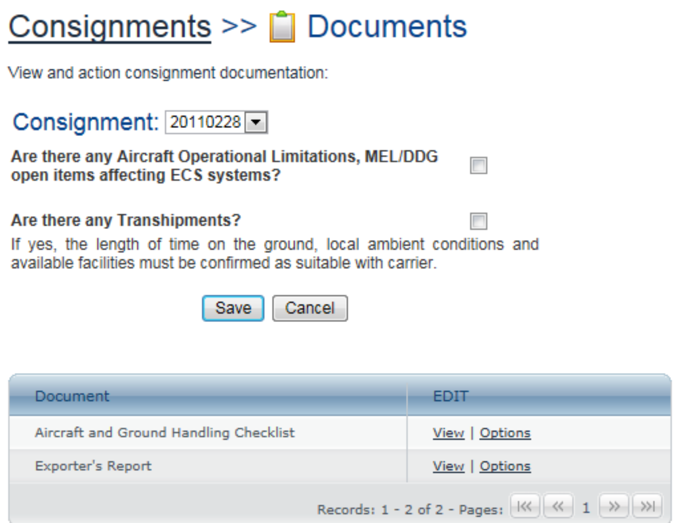
Consignment No	Departure	Consignee	Carrier	Aircraft	EDIT
20110228	28/02/2011	Sino Dairies	Qantas	(Boeing 747-400 BCF)	Load | Docs | Copy || Edit | Delete
20110228_Copy	28/02/2011	Sino Dairies	Qantas	(Boeing 747-400 BCF)	Load | Docs | Copy || Edit | Delete

Add New - Show Filter - Records: 1 - 2 of 2 - Pages: 1

You are now free to modify all the data associated with this new ***Consignment***.

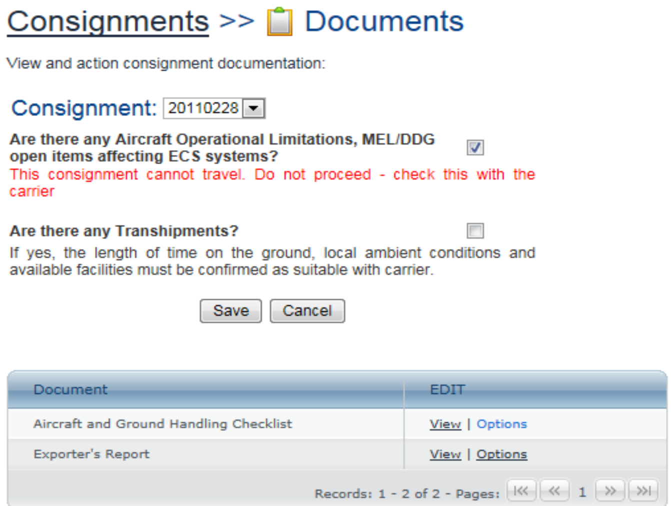
The Documents Page

The ***Documents*** page can be accessed by selecting ***Next*** at the ***Aircraft Hold Environment*** or alternatively by selecting ***Docs*** in the EDIT column of a single ***Consignment*** line of the ***Consignments*** home page. The following page will appear.



This page allows access to the ***Documents*** associated with your ***Consignment***. The ***Aircraft and Ground Handling Checklist*** is required for submission to AQIS together with your Export Documentation. The ***Exporter's Report*** provides more detail of your ***Consignment*** including ***ECS Results***.

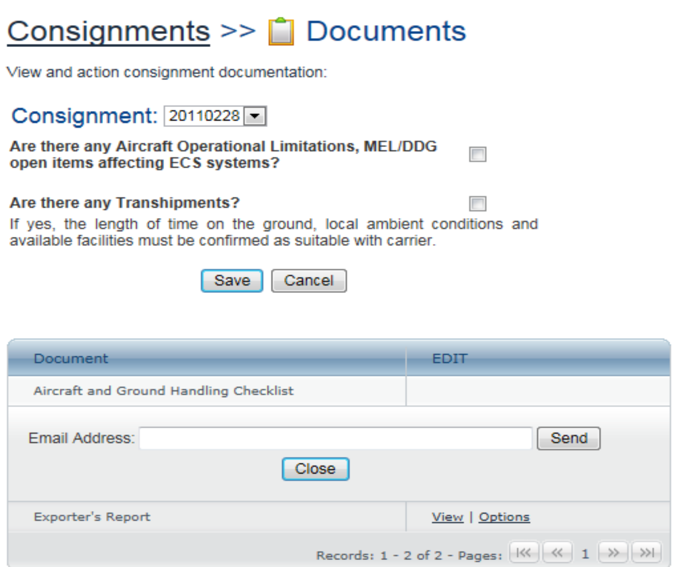
Before proceeding you should take note of the two questions relating to the ***Consignment***. In the first instance you may assume that the ***Carrier's Aircraft*** is fully operation, however at some point prior to shipment the ***Carrier*** must confirm with you that there are not operation issues affecting the ECS of the nominated Aircraft. If you do check the box the following notice will appear.



At this point you will not be able to proceed to your documents. This function may be useful if a proposed ***Consignment*** is cancelled due to ***Aircraft*** malfunction but you wish to keep the detail for a later ***Copy*** process.

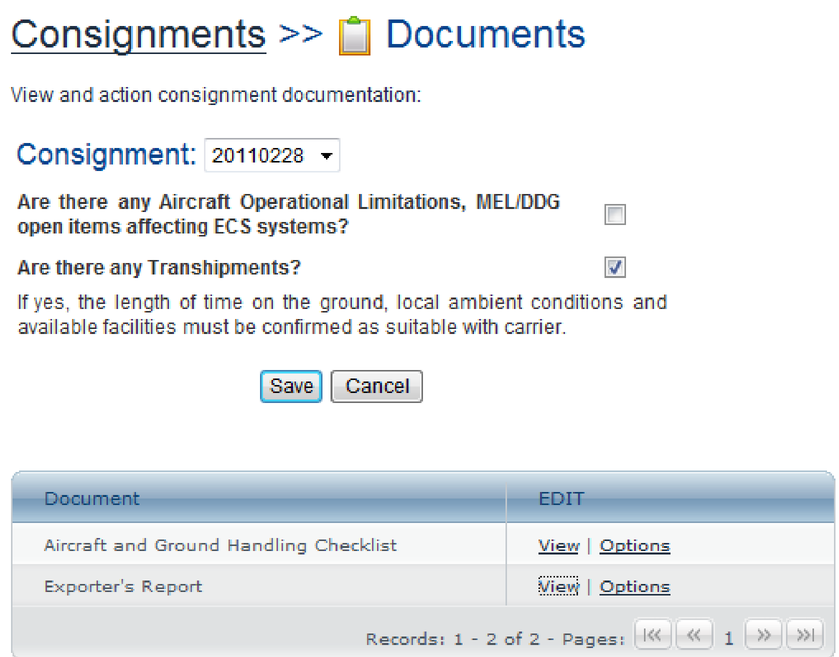
If your ***Consignment*** is to be transhipped you should check the box. Additional detail about the use of ***Transhipments*** can be found in the next section.

Each of the ***Documents*** can be accessed separately via ***View*** in the ***EDIT*** column. The resulting page can be printed or saved locally. In addition the system will be capable of emailing a copy of the Document to your nominated email address by clicking ***Options***. This function will only operate once the email system has been appropriately activated on the server. An example of how the email system works is show below.



Transhipments

The LATSA system is designed for all transit on the one aircraft albeit with one ***Tech Stop***. In the event that your ***Consignment*** requires ***Transhipment*** it is recommend that the box relating to ***Transhipments*** is checked on your first Consignment "leg". This will allow data relating to your transhipment to be manually entered on the Ground Handling Checklist.



In addition to this initial ***Consignment*** leg, it is recommended that each subsequent leg of a ***Transhipment*** have a separate ***Consignment*** listing. This allows you to validate each leg of your flight using different ***Aircraft*** and ECS conditions. It may even be necessary to split the onward ***Consignments*** due to the use of smaller ***Aircraft***.

Please review the section entitled "Copy a Consignment". It is also recommended that each leg be a ***Copy*** of the main ***Consignment*** with some detail altered to match to onward ***Operator, Aircraft*** and flight information. The ***Consignment*** numbers should be quite similar to assist in identifying linked flights later.

Aircraft Ground Handling Checklist

Once accessed from the documents page via ***View***, the ***Aircraft Ground Handling Checklist*** will appear on your screen. This version of the Checklist contains both recorded data and areas on the form for manual entry. The following example is an ***Aircraft Ground Handling Checklist*** which has been generated with a transhipment.

Aircraft Ground Handling Checklist

LiveCorp Nov 2010

Carriage of Livestock by Aircraft

Con # (ECL)	**20110228**	Date:10/05/2011
Aircraft Carrier	**Qantas**	On Approved List
Aircraft Operator	**Atlas Air**	On Approved List
Aircraft Model	**Boeing 747-400 BCF**	On Approved List
Flight No	**QF503**	

Aircraft ECS	Main Hold	**Acceptable ventilation conditions in this hold**
	Lower Forward Hold	**Acceptable ventilation conditions in this hold**
	Lower Aft Hold	**Acceptable ventilation conditions in this hold**

Are there any Aircraft Operational Limitations, MEL/DDG open items affecting ECS systems? **NO**

Limitations applied under ATA Chapters: 21, 26, 36 or 75. Any limitations above under these will affect the ECS systems, especially cargo holds and must be confirmed with carrier. Items include:

- Air Conditioning
- Trim Air Valves
- Temperature Control Systems
- Pressurisation Systems
- Automatic Temperature Control Systems
- Automatic Selection Control Systems

Flight Time: **13 Hrs**

Flight times exceeding 15 hours can be critical if there are any ECS related MEL/DDG items applied, this should be confirmed with the carrier.

Are there any Transhipments **YES**

If yes, the length of time on the ground, local ambient conditions and available facilities must be confirmed as suitable with carrier. If more than 3 hours provide full details of person or organisation supervising the trans-shipment

Flight number................ ETA............................

Flight number................ ETD............................

Name... Contact details.....................................

Are there animal holding facilities at the airport YES/NO.........

Contingency Plan for missed connection

Details...

....

Crate Floor Space .... m² per deck

Crate Headroom .... cms

....

....

LOAD LINES

Head	Animal	Species	Hold	Crate Manufacturer	Rego. No.	Crate Name	Cert. No.	Crates	Density	ASEL
45	Cattle - Adult	Bos primigenius ssp.	Forward	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1480	01/1480	5	0.69	0.68
32	Cattle - Adult	Bos primigenius ssp.	Aft	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1480	01/1480	4	0.77	0.68
270	Cattle - Adult	Bos primigenius ssp.	Main	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1750	01/1750	30	0.69	0.68
347								**39**		

You may print this document directly from this screen. It will generally print on A4 paper through your connected printer. You can also save this document to your local hard drive.

To exit this document it is recommended that ***Participants*** use the Back button in the Internet Browser as closing the document will force the system to log out.

Exporters Report

Once accessed from the documents page via ***View***, the ***Exporter's Report*** will appear on your screen. This report contains more detail regarding your ***Consignment*** and the ***ECS Results*** relating to the ***Load***.

EXPORTERS REPORT

Date: 10/05/2011

Name	**Luke Hogan**	Total Flight Time	**13 Hours**
Company	**Personal**	Total Number Crates	**39**
		Gross Weight	**92045 kg**
Con # (ECL)	**20110228**	Liveweight	**76340 kg**
Consignee	**Sino Dairies**		

				Airport	Date	Time
Aircraft Carrier	**Qantas**	On Approved List				
Aircraft Operator	**Atlas Air**	On Approved List	Departure	**MEL**	**28/02/2011**	**05:00 PM**
Aircraft Model	**Boeing 747-400 BCF**	On Approved List	Tech Stop	**DRW**		
Flight No	**QF503**		Arrival	**PVG**	**1/03/2011**	**04:00 AM**

LOAD LINES

Head	Animal	Species	Hold	Crate Manufacturer	Rego. No.	Crate Name	Cert. No.	Crates	Density	ASEL
45	Cattle - Adult	Bos primigenius ssp.	Forward	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1480	01/1480	5	0.69	0.68
32	Cattle - Adult	Bos primigenius ssp.	Aft	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1480	01/1480	4	0.77	0.68
270	Cattle - Adult	Bos primigenius ssp.	Main	Animal Crates Australia Pty Ltd		Single Deck Cattle Series Version B - 1750	01/1750	30	0.69	0.68
347								**39**		

AIRCRAFT HOLD ENVIRONMENT RESULTS

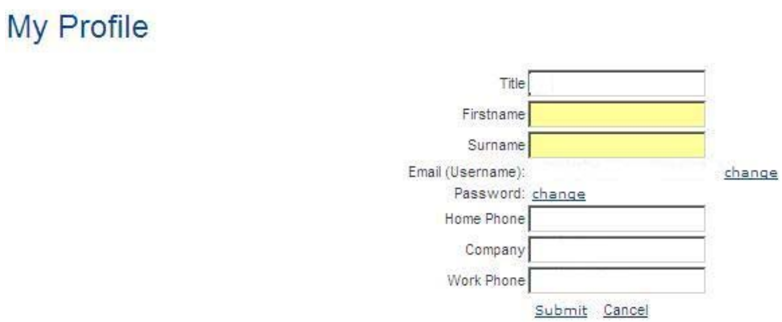
Hold Type	Space Used (%)	Exit Temp. (°C)	Exit RH. (%)	Exit CO2 (ppmv)	ECS Result
Main	100	26	44	2572	Acceptable ventilation conditions in this hold
Forward	100	15	20	1097	Acceptable ventilation conditions in this hold
Aft	100	14	19	1043	Acceptable ventilation conditions in this hold

You may print this document directly from this screen. It will generally print on A4 paper through your connected printer. You can also save this document to your local hard drive.

To exit this document it is recommend that ***Participants*** use the Back button in the Internet Browser as closing the document will force the system to log out.

My Profile

It is possible to alter some profile details in LATSA. Click on ***My Profile*** in the main screen to edit details or change your email address (***Username***) or ***Password***.



Troubleshooting Guide

The LATSA data structure is stable in the sense that data entered will remain in the event of an error. However it is important to use the command buttons for some operations to ensure data is saved before exiting. For instance when altering ***Load*** details such as the number of stock, make sure you use the ***Update*** or ***Next*** buttons. Do not use ***Close*** or press "Enter" if you want to firstly save the details entered, if you do so you will have to re-enter and ***Update*** them.

The software generally warns the ***Participant*** if the information entered is not correctly formatted or missing. However, there are various identifiable events associated with data which will create errors in the program. These situations generally relate to the supporting data entered by the ***Administrator***.

In the ***Administrator*** area there is no particular warning of an invalid entry or one which will cause problems to the ***Participant*** in the program calculations. The first indication that the supporting data is invalid will be a ***Participant*** who will undoubtedly face a screen similar to the one below. The following error occurred while attempting to ***Recalculate*** values for ***Aircraft Hold Environment*** or enter the ***Load*** section of an existing ***Consignment***.

Server Error in '/' Application.

Function does not accept floating point Not-a-Number values.

Description: An unhandled exception occurred during the execution of the current web request. Please review the stack trace for more i

Exception Details: System.ArithmeticException: Function does not accept floating point Not-a-Number values.

Source Error:

```
An unhandled exception was generated during the execution of the current web re
stack trace below.
```

Stack Trace:

```
[ArithmeticException: Function does not accept floating point Not-a-Number values.]
   System.Math.Sign(Double value) +10148408
   LATSA.MyMath.CubeRoot(Double x) in C:\Clients\EnviroAg\LATSA\MyMath.vb:4
   LATSA.HoldEnvironment.CalculateWetBulbTemp(Double pAir) in C:\Clients\EnviroAg\LATSA\
   LATSA.HoldEnvironment.Calculate() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:726
   LATSA.HoldEnvironment.get_AvgHoldTemp() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.
   LATSA.HoldEnvironment.SaveResult() in C:\Clients\EnviroAg\LATSA\HoldEnvironment.vb:61
   LATSA.Consignment.SaveHoldEnvironmentData() in C:\Clients\EnviroAg\LATSA\Consignment.
   LATSA_WebApp.ConsignmentDesign.BindGrid2() in C:\inetpub\wwwroot\LATSA_WebApp\App\Par
   LATSA_WebApp.ConsignmentDesign.ddlRecords_DataBound(Object sender, EventArgs e) in C:
   System.Web.UI.WebControls.BaseDataBoundControl.OnDataBound(EventArgs e) +104
   System.Web.UI.WebControls.ListControl.PerformSelect() +147
   System.Web.UI.WebControls.BaseDataBoundControl.EnsureDataBound() +82
   System.Web.UI.WebControls.ListControl.OnPreRender(EventArgs e) +31
   System.Web.UI.Control.PreRenderRecursiveInternal() +108
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Control.PreRenderRecursiveInternal() +224
   System.Web.UI.Page.ProcessRequestMain(Boolean includeStagesBeforeAsyncPoint, Boolean
```

Version Information: Microsoft .NET Framework Version:2.0.50727.3082; ASP.NET Version:2.0.50727.3082

While errors such as the above are disconcerting to the ***Participant***, they have not been created by the ***Participant***. What has happened is that the ***Participant*** has attempted to do one of the following:

- To use supporting data that is not correctly loaded in the ***Administrator*** area; or
- To use a selection for which there is no supporting data in the ***Administrator*** area.

Changes to base data and constants are not available to the general ***Participant*** and have been placed in a more secure area. However, it is relatively easy for the ***Administrator*** to correct issues relating to the base data. This base data is accessed by all ***Participants*** through their and the objective of the upgrade to LATSA was to centrally co-ordinate this data to make system wide changes easier for everyone to access.

In the event of an error similar to the above it is important to immediately advise the ***Administrator*** and include as much detail as possible about the ***Consignment***. The ***Participant*** will need to make particular reference to:

- The ***Operator***;
- The ***Aircraft***;
- The type of stock;
- The number of animals;
- The ***Crate Manufacturer***;
- The ***Crate Name***; and,
- The number of ***Crates***.

In addition it is often helpful to include screen shots of the warnings or errors relating to the issue.

The ***Participant*** may also find that they cannot select their desired information. This may be the ***Carrier, Operator, Aircraft, Hold or Crate***. If any selection is not available you must contact the ***Administrator*** immediately. In the early stage of development supporting data relating to your usual selections may not yet have been updated. The alternative is that the ***Administrator*** may have not entered, removed or limited access to that selection. This action would apply to all ***Participants***. This would generally be the case for selections that are not yet approved by the industry body or have been suspended because of transportation or safety issues. In any case it is important to get advice on why your selection(s) are not available.

When provided with enough information the ***Administrator*** can attempt to replicate your error, correct the offending base data or advise you of any limitations relating to your choice of selections.