Live Transportation Research and Improvement Initiatives
As a major chicken processor in Canada, MLF recognizes the critical need to identify improved live bird transportation solutions.

In 2014, Maple Lodge Farms established a Transport Working Committee to effect improvements to current hauling technologies and holding (lairage) facilities.

A committee of experts made up of veterinarians, agricultural engineers, ventilation experts, animal behaviourists, livestock transportation specialists and equipment manufacturers -.
This committee is currently conducting transportation studies, focusing on air flow and its effect on temperature, CO2 and humidity gradients within a fully enclosed conventional poultry truck, in order to design equipment improvements and influence industry standards based on solid scientific evidence.
It is well known that thermal challenges (both heat and cold stress) constitute the main threat to the birds’ welfare and survival during transport.

Controlling microclimates that build up on poultry transport trailers is complex.

Achieving a uniform onboard climate is critical to ensure optimal transport conditions for all birds on board, improving welfare and reducing transport related mortality (dead on arrival or DOAs) a measure often used as a transport metric.
DOA influencers

There are many variables influencing in-transport mortality, which is referred to and recorded as dead on arrival (DOA) at the plant.

- Pre-existing condition – disease, injury, environmental stress
- Bird gender and weight
- Overall flock health – nutrition, genetics, flock management, barn conditions
- Catching quality/loading time
- Crate density (related to heat and ventilation)
- Extreme cold or heat
- Humidity
- Poor ventilation – ammonia, CO2
- Feed withdrawal prior to loading
- Trailer configuration—tarps, front/rear board configuration, roof vent configuration
- Time in transit and holding
- Holding conditions
Projects

1. Live Haul Trailer Field Testing
   - Metered trials in “real life”
     - Testing different configurations
     - Validate theoretical models
     - Intensive metering to produce 3D heat maps

2. Computer Modelling
   - Computational Fluid Dynamics (CFD)

3. Statistical Analysis
   - Historical data
   - Field testing data
Live Haul Trailers
1. **Cold temperature management is the biggest challenge during transport**
   - Goal is to manage the microclimates that exist within a fully enclosed trailer, even out heat distribution and control moisture build-up (relative humidity)

2. **Warm weather challenges exist particularly when trailer is stationary**
   - Goal is to avoid warm air built up in the centre of the load and promote air flow

3. **Solution must be practical and economical**
   - Robust equipment to survive rigors of live haul
   - Low maintenance and easily cleaned
   - Maintain current load density
   - Financially feasible
What we know relative to bird welfare and comfort:

- Increased air circulation within the trailer has a positive effect
- For optimum thermal comfort, uniform ventilation is necessary
- Exposure of birds to localized high air velocities should be avoided

In the current configurations of tarped crate container livehaul trailers using passive ventilation, the internal air circulation is often insufficient in some areas and results in the accumulation of heat and moisture in these areas of trailers (microclimates).

We need to:

- protect birds near the exterior from cold air in the winter;
- remove excess heat and moisture from the centre of the load, and;
- redistribute on-board heat created by birds
Live Haul Trailers (crate containers)

Based on these requirements, a brainstorming session with transport and ventilation experts, veterinarians, animal behaviourists and engineers led to the inception of two mechanical ventilation concepts:

- the “down-draft” system
- the “up-draft” system.
Live Haul Trailer Field Testing

Broiler crate container trailers:
Winter Trial Period from November 2014 – April 2015

11 Metered Trials

4 configurations tested for comparisons in paired field runs (same day same barn origin)

Conventional, “Updraft”, “Downdraft” and Perforated tarps

2 – 53 foot-trailer intensive metering trials

Range of average outdoor temperatures between -10 to 5°C
“Down draft” ventilation system

The concept behind the down flow test trailer was to improve air circulation and counteract the effects of temperature stratification by moving roof level air towards the bottom of the trailer.

• Potential to allow bottom row to be utilized (currently kept empty in winter)
• Improve temperature at bottom of load, reducing impact of moisture
• Improve air flow throughout load
“Down draft” Ventilation System

**Design Concept**
- Four columns of crates were removed from back of trailer to allow redistribution of crates.
- This created six 7” gaps per pair of crate columns down the length of the trailer.
- Installed a circulation fan at each 7” gap mounted inside a crate.

![Diagram of ventilation system](image-url)
“Down draft” broiler livehaul trial

Metering plan:

💰 6 modified crates were placed on board at roof level, each containing one 1,200 CFM down draft fan

💰 Temp/RH loggers and Temp/RH/CO₂ loggers were installed between crate gaps 6-7 crates from roof (central in the load).

💰 The logger monitors up to 8 locations with an onboard unit then communicates data wirelessly to a receiver such as a laptop. This unit was developed specifically for live haul metering applications.
“Down draft” trial conclusions

 Trials were conducted to observe difference between the 7" and 2" crate gaps on down flow trailer and found 2” gap impeded fan air flow.

 Trials showed similar results on test trailer (7” gap) without fans, therefore improvements likely attributable to lowered density and increased air flow caused by wider gaps and not to mechanical ventilation (fans).

*It is important to note that ~600 less birds were loaded on the down flow trailer for this trial due to the removal of 48 crates.
“Up flow” Ventilation System

The concept behind the up flow test trailer was to draw outside air into the trailer and distribute this air from the floor of the trailer up towards the roof.

• Potential to allow bottom row to be utilized with exception of modified crates
• Improve air flow throughout load but particularly in worst section behind cab, centre of load.
“Up flow” Ventilation System Livehaul Trials

Design Concept

- Removed a total of 20 crates to allow for onboard up flow ventilation system
- Installed two 250 CFM blowers just after trailer drop
- Each blower was mounted inside a set of modified crates and positioned to blow air through a duct extending towards the front or rear of the trailer.
- Each duct extension had evenly spaced 1 ½” diameter outlets which directed air upwards through the 2” vertical gap between crate columns.

![Diagram of ventilation system](image-url)
“Up Flow” Ventilation System
“Up Flow” Trial

Metering Plan Upflow Broiler Live Haul Trial:

瞿瞿 8 channel temperature logger measured locations near the floor and roof; installed on perimeter crates about 12” – 18” off floor and below roof (in both control and trial trailer)

瞿瞿 Temp/RH loggers and Temp/RH/CO₂ logger installed between crate gaps 7 crates from roof (central in the load)

Temp/RH loggers suspended on chains to prevent restriction to up flow ventilation
“Up flow” Trial Conclusions

- Overall, there was matching trends and similar conditions in the test and control trailers at the front, middle, and rear locations comparing up-flow to standard trailer under moderately cold ambient conditions.

- **Up flow system:**
  - did not have a significant impact on relative humidity levels.
  - had slightly lower CO2 concentrations
  - had slightly less stratification of temperature
  - indicating better overall air quality onboard.

**Note:** Improved air quality on up flow trailer largely considered a result of drawing outdoor ambient air into the trailer throughout the entire duration of transport to MLF. Theoretically this could be addressed simply through strategically placed air inlets.
There was some mixed, moderate improvements in temp/RH/CO2 conditions in some areas of the crate trailers.

In some trials, mechanical ventilation did not adequately de-stratify microclimates within the trailer.

In order to address this challenge, we have to provide adequate air exchange and control air flow movement within the trailer to achieve a uniform environment.
Perforated Tarps

Perforated tarp concept is designed to improve the overall ventilation

- Provide additional air circulation on board
Design Concept

• A test trailer was set up with perforated insert in the driver and passenger side tarps.

• A 600” x 30” strip with 1mm diameter perforations (equivalent to 8% open area) was fabricated along the entire length of the tarps near the roof of the trailer.

• Added approximately 10 ft² of open area to each side tarp for air to pass into or out of the trailer.
Perforated Tarp Livehaul Trials
Conclusions:

();++ In general, the perforated tarp when compared in paired trials to the standard non-perforated tarp:

;++ had more uniform temperatures and relative humidity levels

;++ CO2 levels were less variable likely due to increased mixing of ambient air with air onboard the trailer

;++ Further study is required to understand the factors and their interactions:

;++ perforation diameter, location of perforations, patterns, whether the tarp should be fully or partially perforated

;++ effect on passive ventilation performance.

;++ This is currently being studied via computer modelling.
Limitations of field testing

 бю Arduous and difficult to control variables to ensure test trailer and control trailer are exposed to same conditions in field

 бю Time consuming and expensive - multiple trials are required because of inability to control all variables
Computational Fluid Dynamics (CFD) is the use of applied mathematics, physics and computational software to visualize how a gas or liquid flows, as well as how the gas or liquid affects objects as it flows past. It utilizes equations to describe how the velocity, pressure, temperature, and density of a moving fluid (or gas, such as air) are related.
The Objectives of CFD modeling are:

- To simulate the real livehaul onboard conditions such as air velocity, temperature and humidity for 53 foot trailer (broilers, crate loaded) for cold (winter) period, when tarp is “on”;

- To develop mapping for temperature, humidity, inside and outside pressure, differential pressure and air velocity distribution (velocity and directions) for a passively ventilated loaded moving trailer;

- To determine optimal ventilation configuration (size and location of air inlets and outlets).
Using CFD software constructed two 3-D computer models
- broiler crate transport truck and trailer
- hen dolly truck and trailer

A base configuration of the trailer ventilation scheme with boundary conditions was selected and modeled.

The CFD simulation predicted localized air flow patterns, velocities, and temperatures through the trailers.
  - Validated by the in field intensive metering livehaul trials

These models have elucidated how air currently moves through the trailers and the problems inherent in each.

Simulations are now being run with relocated/redesigned air inlets and outlets aimed at addressing problem areas within the trailer.
Model Overview

Baseline Configuration: Side View

Trailer: Type M (Chickens)
Number of Cages: 784
Number of Chickens per cage: 12
Total Number of Chickens: 9408
Trailer Configuration

Gap: inner front wall and first crate stack

Gap: inner back wall and last crate stack
Model Overview

Tarp Gap

Tarp Gap: Driver side

Tarp Gap: Passenger side

Tarp Gap: Below roof opening, full length trailer
Model Overview

Trailer Configuration: Chicken Cage

Top Face

Side Face

Bottom Face
Boundary Conditions

- Ambient conditions = 5°C (41°F)
- Relative Humidity = 70%
- Wind = 80 km/h
CFD Results – Velocity & Directional vectors

Air movement above crate stack

Open Front Vent
Model Overview

Boundary Conditions

Baseline trailer

- Top vent: open to ambient
- Tarp (solid wall) 2.5" gap at top

Heat release rate = 8.4 W/chicken
Water vapor rate = 15 g/h/chicken

Wind = 80 km/h

Ambient conditions = 5°C (41°F)
Relative Humidity = 70%
Model Overview

Configuration: Alternative #1*
Note: baseline configuration by contrast is tarp fully closed with only roof vent open
CFD Results - Velocity

Baseline (fully enclosed, roof vent open)

Alternate1
CFD Results – Temperature (note scale)
CFD Results – Relative Humidity

Baseline

Alternate1
Conclusions

- Small changes in air inlet and vent configuration result in significant changes in temperature, relative humidity and air velocity within the trailer.
- Several simulations utilizing different configurations/locations of air inlets and exhaust have been run.
- Enable scientific rationalization of sensor location.
- Optimized trailer configurations are currently in field testing.
Questions/Comments?