Challenges of Barn Design and Performance in Automated Milking Systems

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The US AMS Challenge:

- How do we design and manage an AMS unit to improve milk per cow per day and be labor efficient?

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UW Upper Midwest AMS Survey 2018

- 42 predominantly Holstein herds
- Mean time milking in AMS: 4.1 years (minimum >1yr)
- Mean herd size: 209
- 83% new, 17% retrofit
- 60% Lely, 31% DeLaval, 4% AMS Galaxy, 2% GEA, 2% BouMatic

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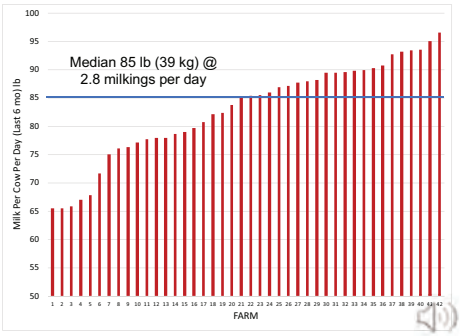
Milk per Cow (42 AMS herds)



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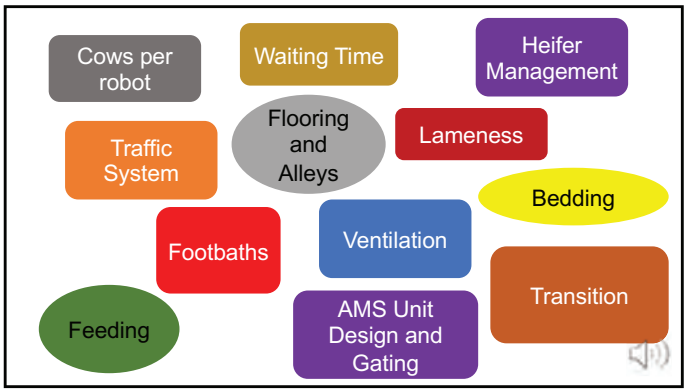

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Theoretical Robot Capacity

- Robot availability 22 h per day
- Box time ~7 mins per cow – 60/7 = ~8 cows milked per hour
- 22 x 8 = 176 milkings per day
- At 2.8 milkings per day = 63 cows per robot

- BUT this forgets that cows are cows!

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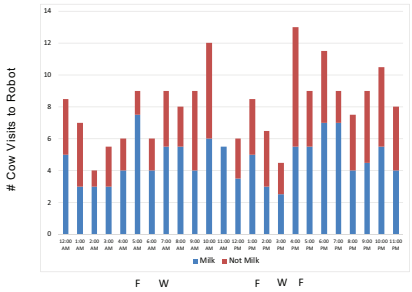
Daily Variation in Robot Visits



The desire to be milked is not constant throughout the day!

W=Robot washes
F=Fetch cows

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No threshold for cows per robot exists in the literature….

- Very little data to support planning to milk more than 60 cows per robot using current settings installed by manufacturer
- Mean cows per robot reported in literature in US and Canada ~49-56 cows
- Greater numbers decrease robot visits and increase fetch rates
- Cow behavior dictates that the theoretical maximum will not be achieved in practice!

- Plan for 55 cows per robot!

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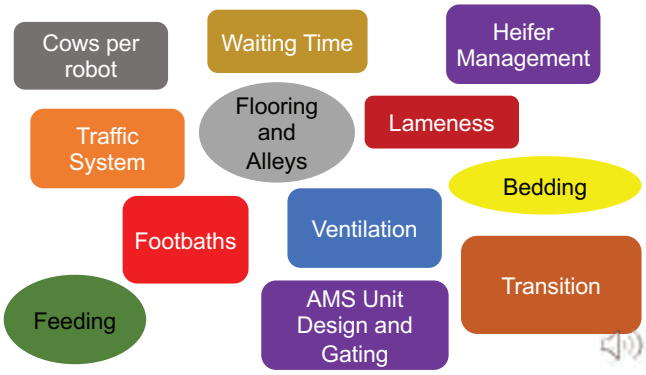

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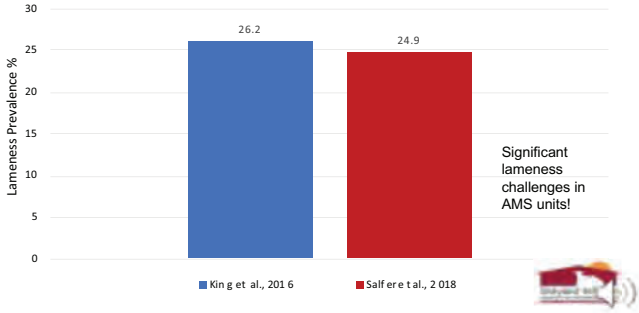
Lameness Prevalence in AMS Herds



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Cow-level associations of lameness, behavior, and milk yield of cows milked in automated systems

Lame cows compared to non-lame cows in 41 AMS facilities in Canada:

- Produced 1.6 kg (3.5 lb) /d less milk
- Milked 0.3 fewer milkings per day
- 2.2 time more likely to be fetched

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Easy access to a chute for individual cow attention is essential

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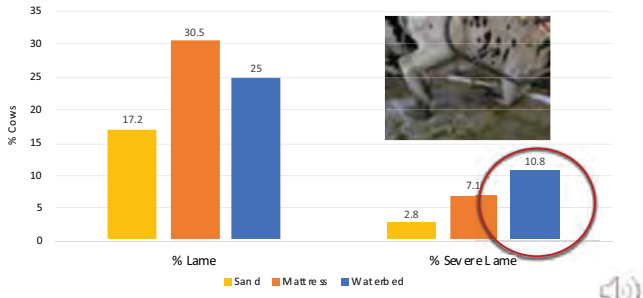
Impact of Stall Base on Lameness in AMS Units



Salfer et al., JDS 101:8586-8594, 2018 from 54 AMS units in Upper Midwest

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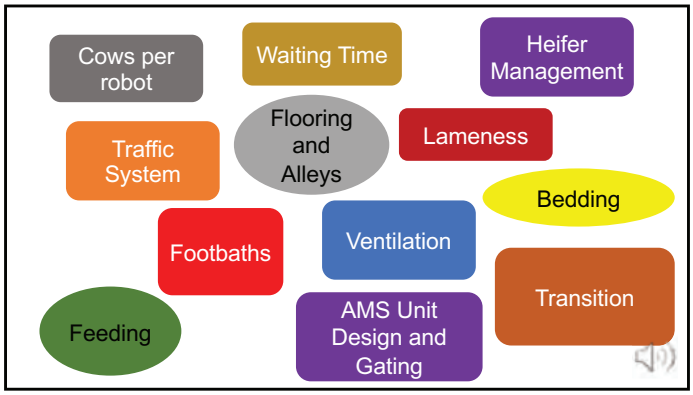

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Deep loose bedding is best for cows!

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Sand Challenges in Robots

- Precludes slatted flooring – GOOD!
- Requires V-shaped scrapers for bedding access (or manual scrape alleys)
- Sand wears the nylon retractor cables and pulleys in LELY units
- Sand scratches the camera lens in DELAVAL units
- ???? GEA units

- We believe most of these issues are manageable!

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Bedding access and scrapers in AMS facilities

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UW AMS Survey 2018 – Stall Base

- 57% Sand, 24% Mattress, 17% Waterbed, 2% Manure Solids
- Mean milk per cow per day significantly different between deep bedding (sand/manure solids) and mattress (P<0.05), and deep bedding and waterbed (P<0.05)
  - Sand/manure deep bed 85.8 lb (39.0 kg)
  - Mattress 79.0 lb (35.9 kg)
  - Waterbed 78.1 lb (35.5 kg)

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Cows per robot

Waiting Time

Heifer Management

Traffic System

Flooring and Alleys

Lameness

Bedding

Footbaths

Ventilation

Transition

Feeding

AMS Unit Design and Gating

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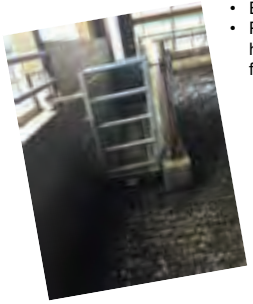
The AMS Footbath Challenge



- Exit lane footbaths decrease robot attendance?
- Pushing cows through a footbath on a crossover has never worked well and producers don't bath frequently enough with this approach!

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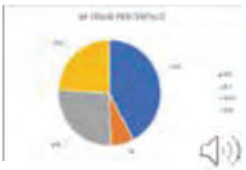
Voluntary footbaths ….
do not work!



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The Ideal Footbath

- 10' (3-3.7 m) long
- 24" (0.6 m) wide sloped to 3' (1 m) at 3' (1 m) high
- 10" (25 cm) high step

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Cows must be selected from the robot to walk through the footbath as they leave the robot area and/or return to the resting area

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Having to put the footbath in a cross alley is a significant drawback to the L-shape, cross-way and side installation designs!

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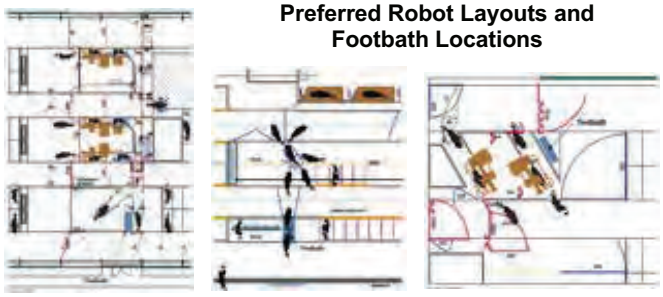
Preferred Robot Layouts and Footbath Locations



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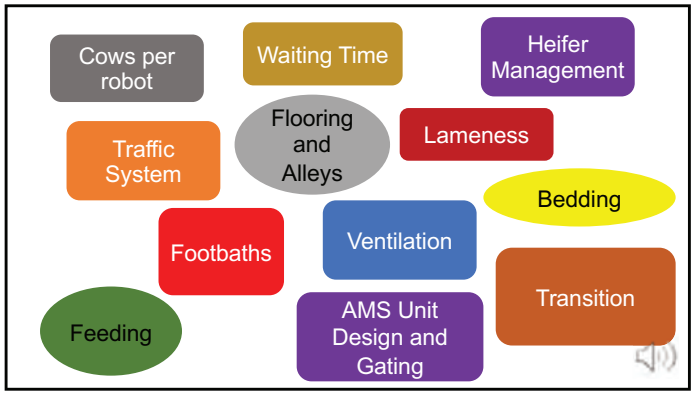

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Getting heifers used to robots…

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Getting heifers used to gates …

….it's not intuitive to a heifer to know that she must push against a gate to get somewhere – she has to learn it!

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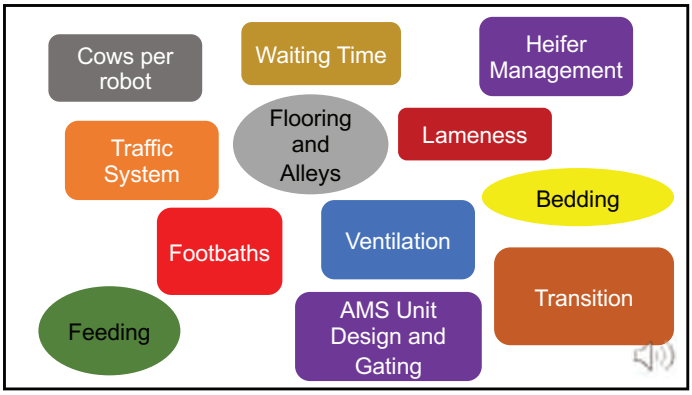

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UW AMS Survey 2018 – Fresh Cows

- Most AMS units don't separate fresh cows from other lactating cows for very long!
  - DIM fresh mature cows 0-30 (mean 5.1 days)
  - DIM fresh heifers 0-30 (mean 6.6 days)
- 38% of herds separate fresh cows from lactating cow group for 1 day or less (mean 81 lb (36.8 kg) milk per cow per day)
- 7% of herds separated cows for 14 or more days (mean 88 lb (40.0 kg) milk per cow per day)

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24/7 fresh cow access to the robot

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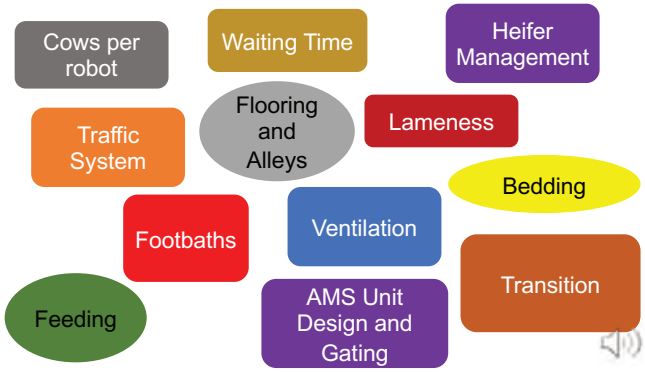

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Alley space is incredibly important in an AMS unit – they allow cows to move toward the robot unhindered!

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Alley Width Recommendations

Alley Type	Recommended Alley Width feet (m)	
	Conventional	AMS
Stall Alley	10 (3.0)	11 (3.4)
Feed Alley	12 (3.7)	14 (4.3)
Feed and Stall Alley	13 (4.0)	15 (4.6)

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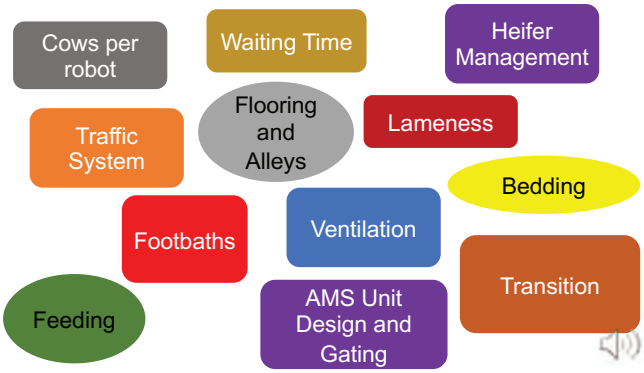

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Traffic Systems

- Free-flow
- Guided-flow
- Hybrid (Semi-Guided-flow)

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Free- or Guided-Flow?

- Increased milk per cow with free-flow vs. guided-flow traffic (Tremblay et al., 2016), but in survey only 7% herds had guided-flow and all farms used Lely units, which are biased toward free-flow!
- Each strategy has pros and cons
- Individual farm circumstances should drive the decision
- Facilities can be designed so that both strategies can be adopted

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AMS Traffic Systems – Free-Flow

Pros

- Cows have the freedom to move around the pen – go to the bunk when fresh feed is delivered
- Lower cost – fewer sort gates
- Cows do not get trapped waiting to visit the robot
- Highest producing herds use free-flow

Cons

- Often herds feed more pellet in the robot
- Operation requires more fetching of cows
- Makes footbath use and gating more complex
- May need more FTEs to operate

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AMS Traffic Systems – Guided-Flow

Pros

- Easier to manage, potentially with less labor
- Less fetching of cows
- Feed less expensive pellet in the robot
- Sort options into VIC group/footbath when exiting commitment pen

Cons

- Cows may not be able to access fresh feed at the feed bunk (solved with Hybrid-Flow)
- Cows get trapped in commitment pen for longer periods (solved with alerts)
- Lower milk production being achieved on average
- Still have to fetch cows

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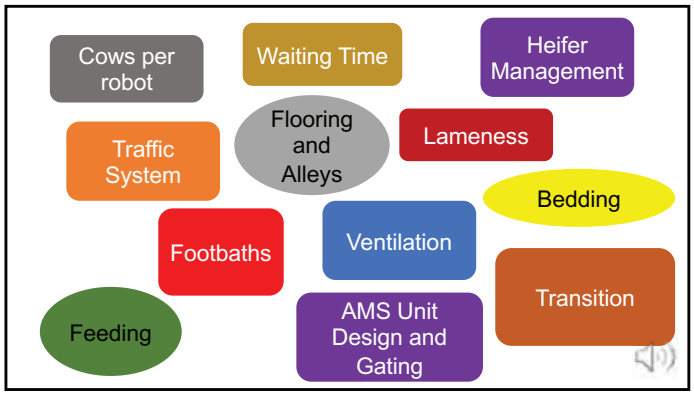

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Wait Time for Milking in GF and FF Traffic Systems
(Solano et al., 2020 unpublished)

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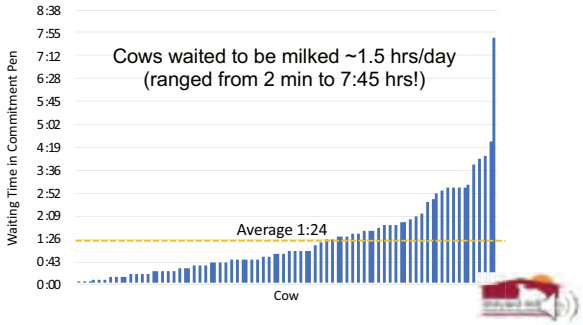
Daily waiting time (hh:mm per day) to be milked in a guided-flow



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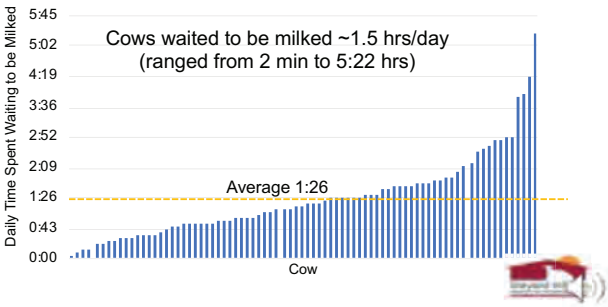
Daily waiting time (hh:mm per day) to be milked in a free-flow



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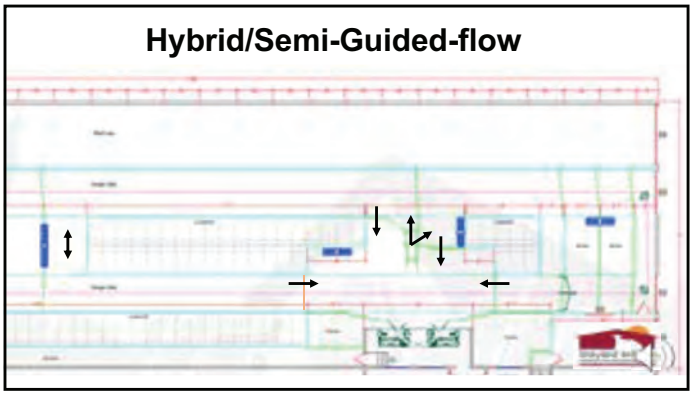

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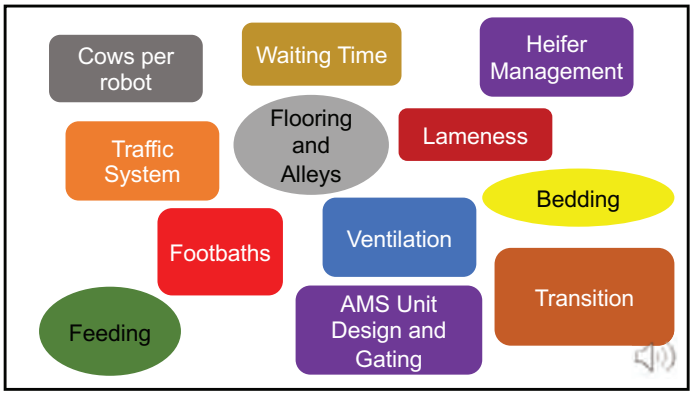

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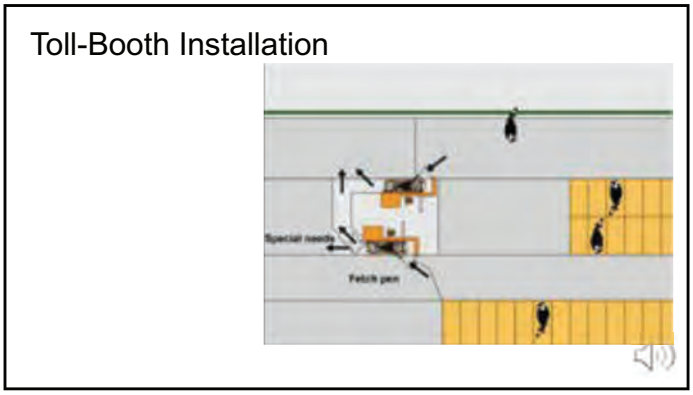

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Not this!

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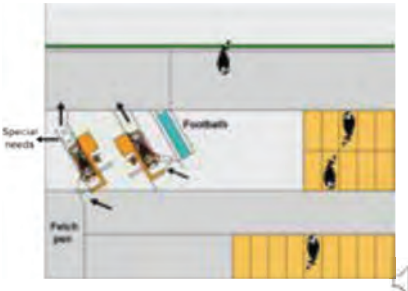
Herring-bone Installation



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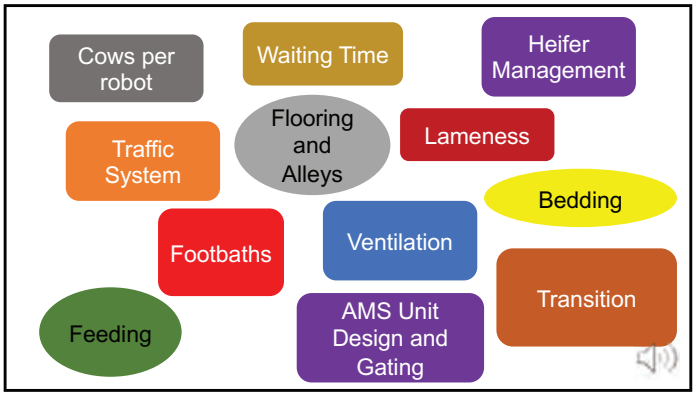

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AMS Ventilation Challenges

- Sideway installations block the sidewall inlet in natural barns
- Crossway installations block airflow in a tunnel barn
- The robot room blocks inlets and airflow in a cross barn
- Need for climate control around the robot

- While commonly used in AMS units, HVLS fans struggle to provide cooling air speeds!

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Specific AMS Solutions

- Dead air in robot room shadows
  - Deliberately make robot waiting area hostile – NO!
  - Provide recirculation fans to improve air flow – YES!
- Robot or milk room blocks inlet area or limits fan mounting area
  - Build inlets around side and top of milk/robot room
  - Positive pressure fans to force fresh air into areas with dead air movement

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Add fans to move air in the robot waiting area!

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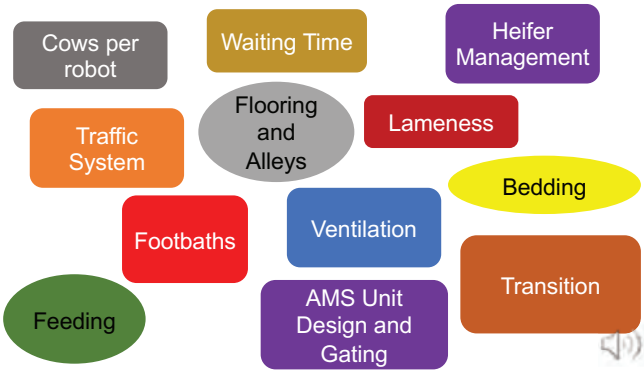

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Conventional vs. AMS Units

Conventional (Cook et al., 2016)	AMS (Salfer et al., 2018)	AMS (Halbach et al., 2019)
70% deep bedding	31% deep bedding	60% deep bedding
0% slatted flooring	22% slatted flooring	11% slatted flooring
73% manual manure removal	26% manual manure removal	2% manual manure removal
100% footbath mean 4.5 X per week	70% footbath and only 27% >3X per week	96% footbath and only 18% >3X per week
TMR fed	PMR fed with pellet in robot	PMR fed with pellet in robot
13% lameness	25% lameness	Not observed
~90 lb (41 kg) milk	~75 lb (34 kg) milk	~83 lb (38 kg)

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AMS General Design Priorities

- 55 cows per robot max to limit fetch rate and optimize robot visits, minimum 2 AMS units per pen
- Free-flow or Hybrid vs. Guided-flow
- Toll-booth, Herringbone or Island preferred designs with selection through a footbath
- Deep loose bedding – sand!
- Sufficient feedbunk space per cow – minimum 24" or 60 cm per cow in the main lactating cow pen
- 24/7 fresh cow access to robot for 10-21 days
- Heifer gate training
- Expert gating and flow modeling

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Thank you!

Road Map to Fatty Acid Balancing

Palmitic to Oleic Balance
Improve milk fat, milk & body condition

Palmitic 16:0 ↑ milk fat more than milk yield

Oleic 18:1 ↑ digestibility of all fatty acids, milk production & body condition

1% Palmitic and 1% Oleic for balanced energy partitioning (%DM)

Manage 18:2 & Rumen Exposure
Too much 18:2 = ↓ milk fat production

Linoleic 18:2 Found in corn, corn silage, distillers, cottonseed
Too much unprotected 18:2 = ↓ milk fat

300+ grams is considered a milk fat risk factor

Omega-6 to Omega-3 Balance
Improve immune health, milk & repro

Omega-6 18:2 Inflammatory = lost energy to immune

Omega-3 EPA DHA Anti-inflammatory= ↑ milk & repro

5:1 or ↓ ratio for optimal results in lactating cows

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