The University Of Sheffield. / AMRC Advanced Manufacturing Research Centre

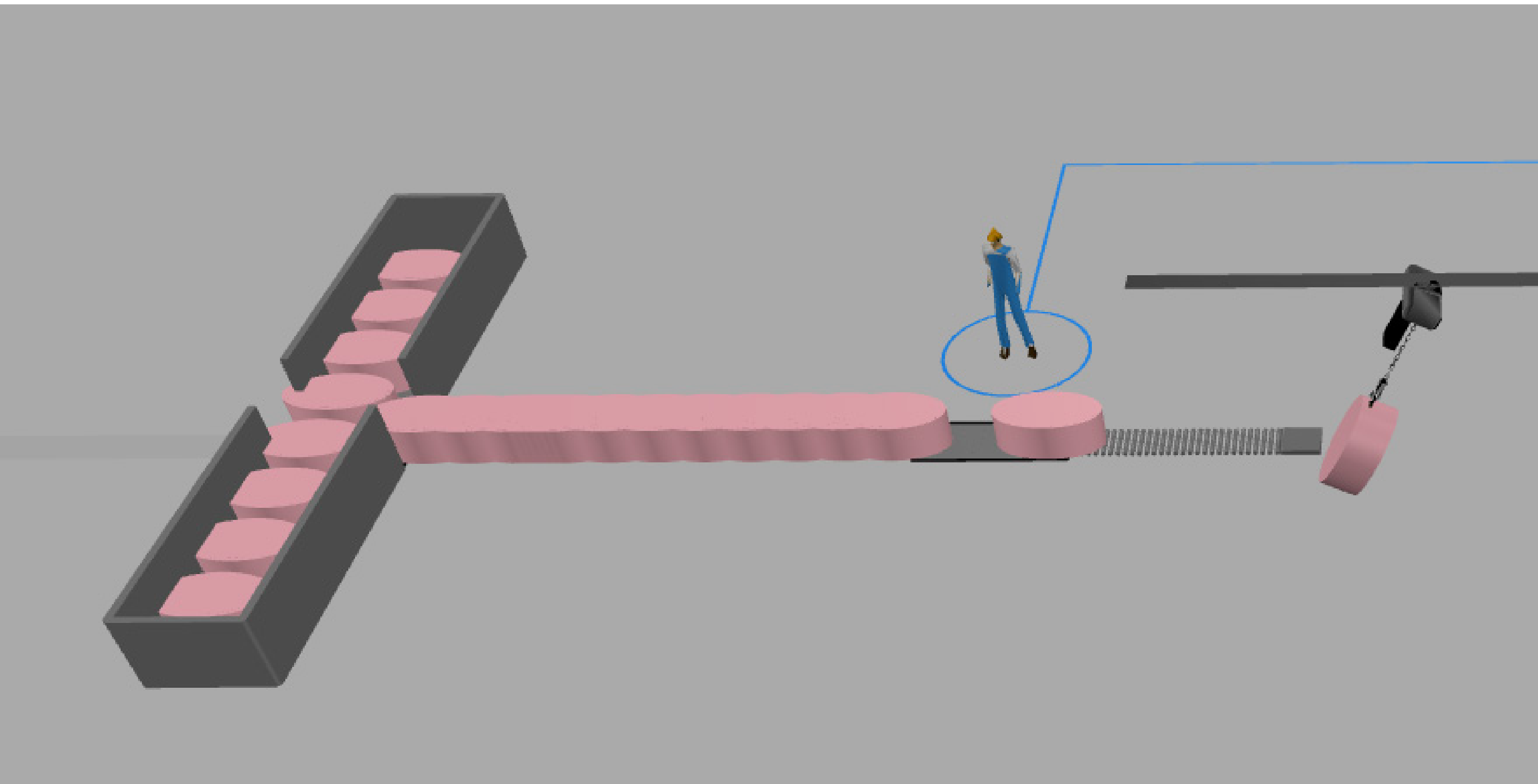
Manufacturing Intelligence
Case Study

A generic abattoir simulation model:
bringing the food industry into the 21st century

Challenge

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) Manufacturing Intelligence Team was challenged with investigating the effects of technology interventions at different critical control and inspection points within an abattoir to help develop a strategy for balancing technology and workforce deployment in a 21st Century abattoir environment.

It was undertaken as part of a Science and Technology Facilities Council (STFC) and Food Standards Agency (FSA) joint funded project with the University of Sheffield. The project explored improvements for bringing the industry from the 18th Century - a lack of advanced technology - into the 21st Century to enhance the delivery of the FSA's official controls and improve meat safety, traceability and authenticity.



Gas stunning and shackle carcass operations in 3D animation.

This project was supported by the Food Standards Agency (FSA) and Science and Technology Facilities Council (STFC) Food Network RC grant reference ST/V001450/1.

CATAPULT High Value Manufacturing

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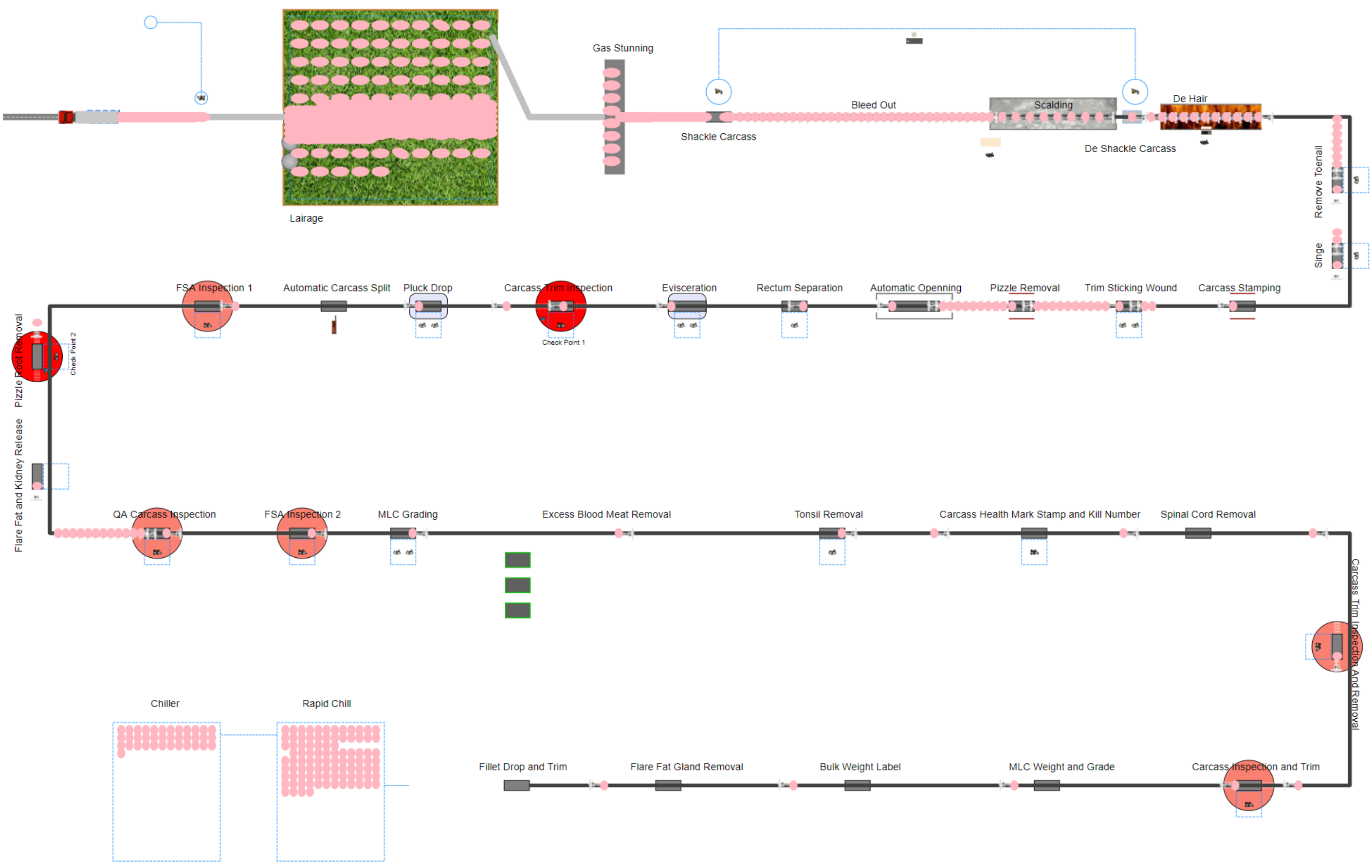
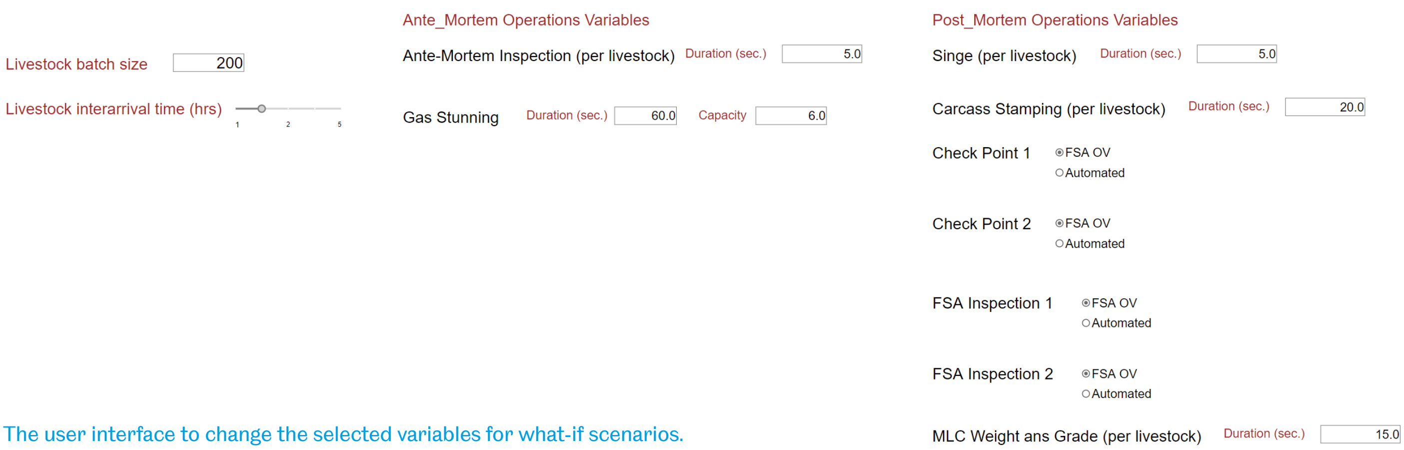
Background

The meat industry is complex, and there are many areas involved: animal welfare, food hygiene and traceability. The roles of meat inspectors and other related professionals are therefore critical in ensuring that products intended for sale are fit for human consumption. Poor working practices and a lack of proper examination of carcasses can have serious consequences for consumers. A digital test bed, where technology interventions could be investigated to increase the efficiency of its operations, could bring significant benefits to the meat industry.



A 2D animation showing the abattoir simulation model and process flow.



The user interface to change the selected variables for what-if scenarios.

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Innovation

In order to provide insights into how abattoir processes - particularly the inspection related processes - can be transformed using digital technologies, a generic and adaptable digital simulation model of the process flow for meat production - in this instance, ham - was developed.

Ham production processes in the UK are guided and controlled by the Food Standards Agency (FSA). The process flow in UK abattoirs is similar in terms of the sequence of the processes. The slaughter of livestock involves three main stages: lairage, stunning, and slaughtering.

Prior to slaughter, animals are held in lairage pens, which are areas where animals are rested on the way to slaughter. These should display stock density notices, the date, time of arrival and contain adequate facilities for feed and water. These are checked by the FSA Official Veterinarians (OVs) who also carry out ante-mortem inspections of the animals to identify any conditions, either physiological or disease-related, that would cause adverse effects to human or animal health.

Animals are then led to a stunning pen through walkways in single file. Stunning is carried out to render the animal insensible to pain; only once this has happened can it be slaughtered. There are different methods of stunning. Gas stun is one of them. Once the animal has been stunned, it is moved to the bleeding area. After bleeding, carcasses are sent to evisceration before going through splitting, labelling and chilling processes.

This image shows the process flow logic of the simulation model.

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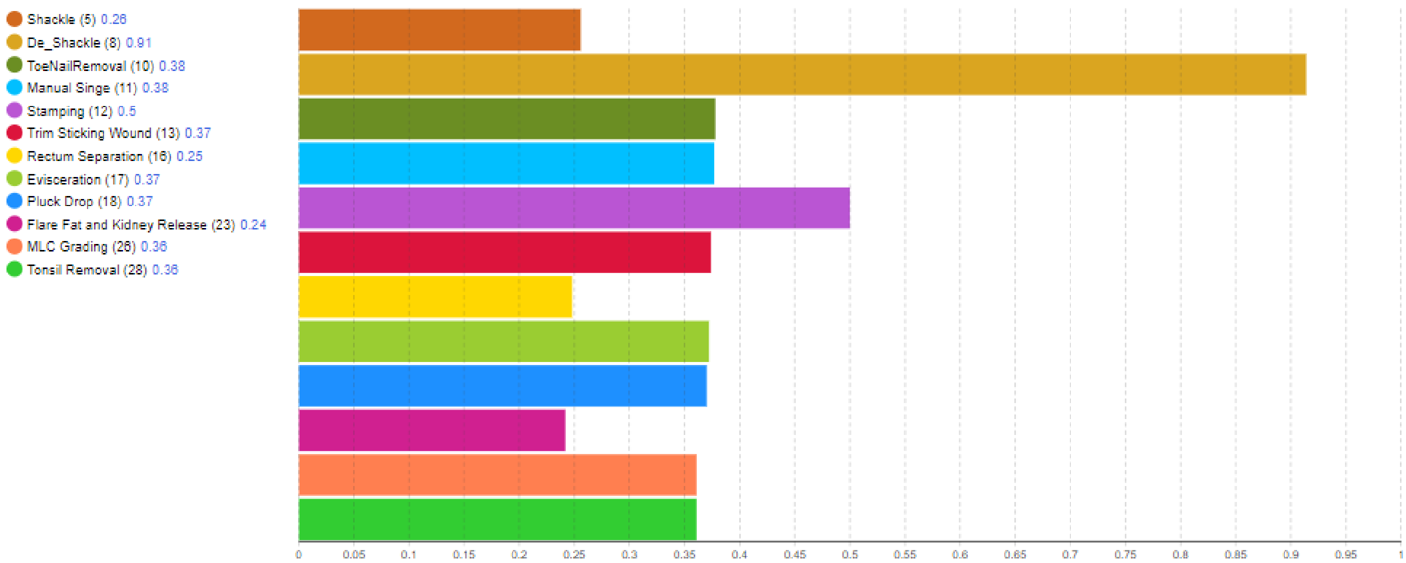
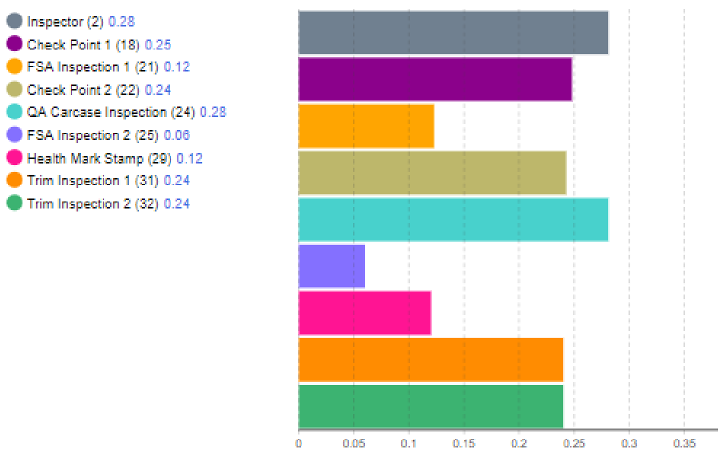
Inspections are carried out at various stages during the process flow. It is a highly stochastic process as a considerable part is done manually and the quality of the livestock differs from batch to batch. From the point that the carcass is shackled, the stunning processes continue on an overhead conveyor until the last operation, which is fillet drop and trim. After this operation, the fillets are sent to a rapid chill and chiller. After staying in the chiller for about a day, the fillets are sent out.

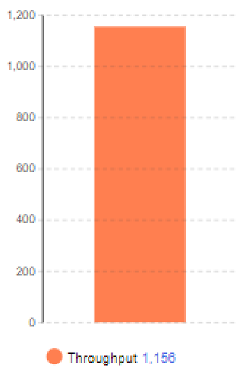
Process flow - from the point of receiving the livestock to chilling the fillets - is defined in the simulation model using AnyLogic software's discrete event simulation capability. Operations are divided into 'Ante-mortem' and 'Post-mortem' stages. All the resources including workers, OVs and machineries are integrated into these stages. Process flow logic is enhanced with the Material Handling Library of AnyLogic software. Post-mortem operations are placed on a conveyor system which provides a more reliable representation of the real-life processes. In addition, this library allowed for defining the length, speed and capacity of the conveyors which makes the model easily adaptable to any specific abattoir layout.

Both 2D and 3D animations were developed for this generic model which helps in effective communication, verification and validation, and experimentation. It also leads to an improved understanding of the real system and makes it easier to detect inefficiencies in the process flow.

The simulation model is enhanced with a user interface and a result dashboard. This user interface allows the stakeholders to run their own experiments on a subset of variables in order to test various technology interventions under various abattoir settings. The dashboard gives insights on the throughput, machinery usage, worker and OVs utilisations.







A KPI dashboard developed as part of the simulation model output.

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Result

Within the scope of this project, several scenarios have been investigated using the developed simulation model to provide a proof of concept. The project consortium was led by the University of Sheffield and included the University of Manchester, University of York and LeanSig Limited; it was supported by STFC and FSA. The consortium explored the following possibilities to advance abattoir processes:

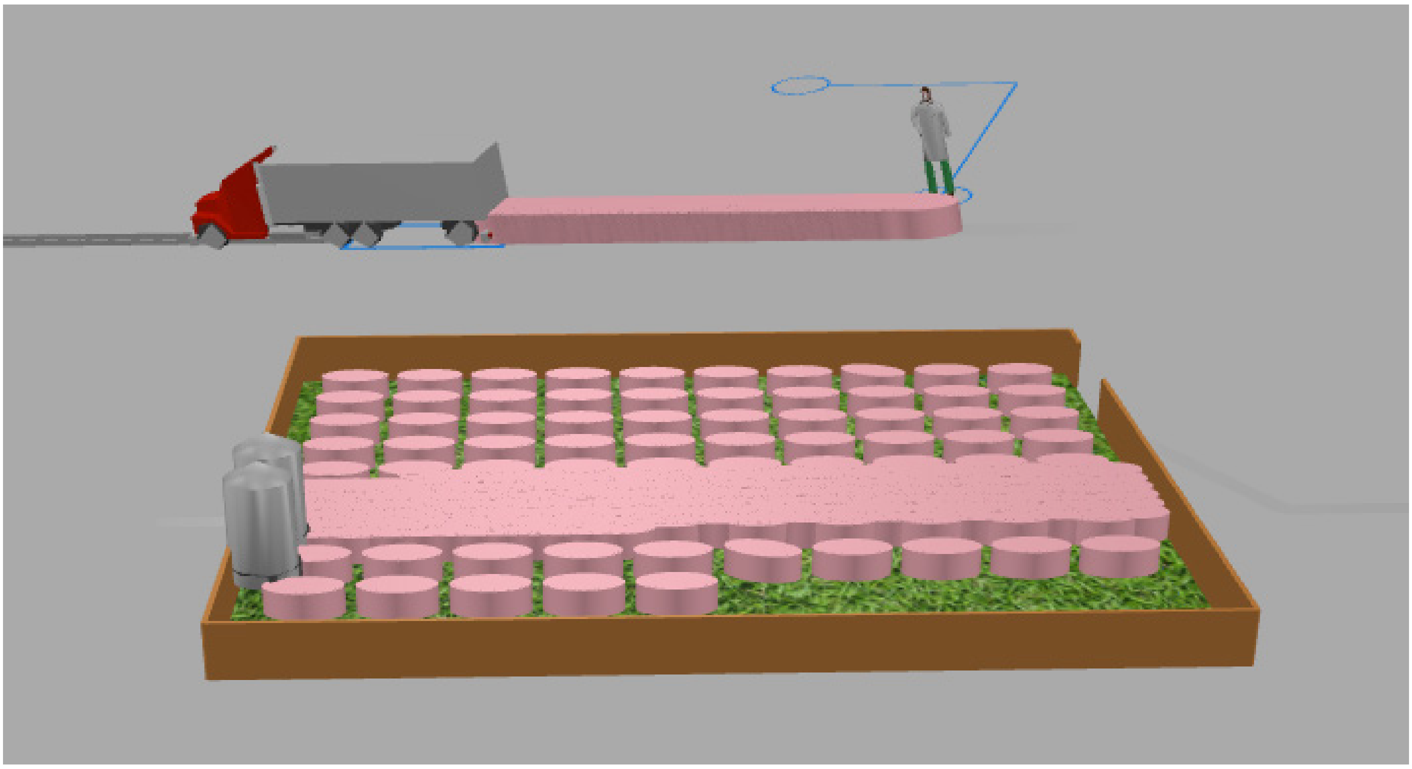
- **Introducing AI technology to the Food Standards Agency (FSA) inspection processes:** Introducing image detection (AI) technology to FSA inspection processes would not just decrease the process time but also increase reliability of the inspection and release the assigned Official Veterinarians (OVs).
- **Automating carcass stamping process:** If this is currently handled manually, then automating this process would shorten the process duration up to four times. As a result, the process would become four times faster.
- **The technological improvements brought about by applying the above scenarios together, would free up OVs for bottleneck inspection processes and increasing batch sizes:** This complex scenario is set up to check the additional capacity to increase production.

Introducing image detection (AI) technology to inspection processes would decrease the process time and increase reliability of the inspection.

Introducing image detection technology to inspection processes reduced the workload of OVs significantly. This frees up the OVs and allows them to carry out more value-added tasks such as being assigned to bottleneck check points within the process flow.

Automating the carcass stamping process increased the throughput slightly. Utilisation of workers stayed below a certain level which shows that the workers might be able to handle a slight increase in livestock batch sizes.

As a result, an additional run has been conducted where both scenarios were applied together with increased batch size. The result showed that the last scenario increased the throughput. Moreover, it balanced the utilisation of the workers and the OVs.



Ante-mortem inspection and lairage shown in 3D animation.

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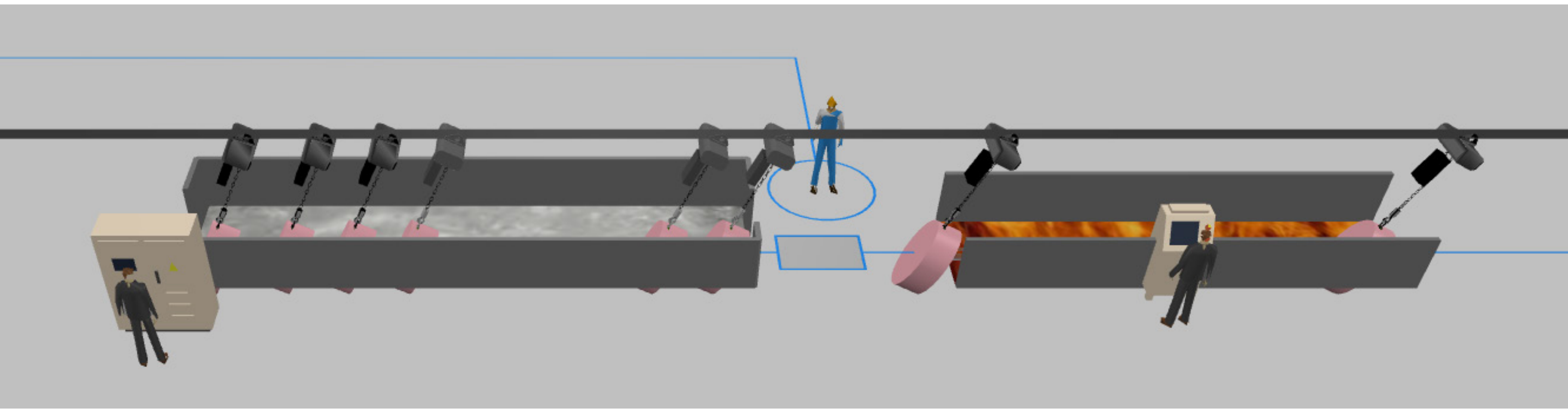
Impact

The developed generic simulation model on the abattoir process flow provides insights into how various abattoir processes including inspection can be transformed using digital technologies. As the model is adaptable, it will continue to help the Food Standards Agency (FSA) to understand the impact of technology intervention at different critical control and inspection points. This will help develop a strategy for the right balance of technology and workforce deployment in a 21st Century abattoir environment. It will guide the FSA to equip its inspectors with the technologies needed to function more efficiently and accurately.

In addition, this model can be easily transformed to a digital twin by populating it with live data through appropriate sensors and Internet of Things (IoT) technology. Digital twins – a first for the meat industry – when scaled up, would provide a risk-free platform to observe the current state of processes and experiment with transformation strategies before committing to real investments. For example, the in-depth process data along with scenario modelling would help meat processing companies to understand their process capabilities, efficiencies, and challenges.



Acknowledgements

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