

2026-27 HIVE Summer Internship Project

ColdChainXR: Immersive Decision Support for Frozen-Food Supply Network Design

Primary Academic Supervisor

Dr. Ponpot Jartrillaphand

Project Background

Frozen-food import supply chains require interconnected decisions about shipment size, transport mode, cold-storage configuration, inventory placement and customer distribution. A decision that reduces freight cost may increase storage requirements, inventory exposure, delivery time or the risk of stock shortages. These trade-offs are difficult to interpret using separate spreadsheets, maps and charts.

Our research investigates optimisation, simulation and decision-support methods for multi-period inventory and distribution systems. This includes inventory-routing problems, where delivery quantities, customer visits, vehicle routes and inventory levels are coordinated over time. ColdChainXR extends this research to the broader strategic design of imported frozen-food supply networks.

The project will use synthetic data to represent a product moving from an overseas processor through ports, refrigerated transport, one or more Australian cold stores, an optional distributor and retail or food-service customers. Students will explore scenarios such as LCL versus FCL shipping, one large shipment versus several smaller shipments, centralised versus decentralised storage, and direct delivery versus distributor delivery.

Rather than producing another conventional dashboard, the project will investigate how high-resolution and immersive visualisation can reveal product flows, inventory accumulation, facility utilisation and cost-service trade-offs. The student will combine supply-chain simulation, interactive visual analytics and Curtin HIVE facilities to create an engaging research prototype for exploring alternative network designs.

Project Description, Expected Outputs, Possible Stretch Goals

The aim is to design and evaluate an immersive decision-support prototype for comparing frozen-food cold-chain network structures. The student will develop a manageable synthetic simulation and investigate how coordinated 2D and 3D visualisations help users understand trade-offs between cost, inventory, capacity, lead time and service.

Expected outputs:

- A synthetic cold-chain dataset and simulation covering an overseas processor, ports, refrigerated transport, cold stores, a distributor and customers.
- Interactive controls for comparing LCL and FCL shipping, shipment size and frequency, one or multiple cold stores, centralised or decentralised inventory, and direct or distributor delivery.
- A decision-support prototype showing total cost, cost per kilogram, stock availability, storage utilisation, delivery lead time and service level.
- Coordinated geographic, temporal, inventory and financial views for the HIVE Tiled Display.
- A stereoscopic space-time network view for the HIVE Wedge, showing shipments and inventory moving through the network.
- A small evaluation examining whether the visualisations help users compare scenarios and identify bottlenecks.
- Documented code, synthetic data, final report, presentation and HIVE demonstration.

Possible stretch goals:

- Incorporate route-level solutions from an existing inventory-routing model.
- Add uncertainty scenarios such as demand variation, shipment delay or facility-capacity disruption.
- Produce an immersive Cylinder demonstration.
- Add multi-objective comparison or automated scenario ranking.

The core project does not require a new optimisation algorithm or confidential commercial data. The student will have meaningful ownership of the visualisation design, prototype and evaluation.

Links to background reading and any relevant recent work in the field

- Curtin HIVE visualisation systems:
<https://hive.curtin.edu.au/visualisation-systems/>
- Fonnet and Prié — Survey of Immersive Analytics:
<https://ieeexplore.ieee.org/document/8770302>
- Iyer et al. — Cold Chain Optimisation Models: A Systematic Literature Review:
<https://www.sciencedirect.com/science/article/pii/S0360835225001184>
- Fan et al. — Trading Off Cost, Emission and Quality in Cold-Chain Design:
<https://www.sciencedirect.com/science/article/pii/S0360835221003466>
- SimPy — Discrete-Event Simulation for Python:
<https://simpy.readthedocs.io/en/stable/>
- Plotly and Dash — Interactive Visualisation and Analytical Applications: <https://plotly.com/python/getting-started/>
- Gurobi Optimizer — Mathematical Optimisation Software:
<https://www.gurobi.com/solutions/gurobi-optimizer/>

What type of visualisation will the student develop or produce?

An interactive visual analytics system combining a high-resolution scenario-comparison dashboard with a stereoscopic 3D space-time model of a frozen-food cold chain. It will visualise facilities, shipment flows, inventory levels, storage utilisation, costs, lead times and service levels across alternative network designs. The Tiled Display will support coordinated views, while the Wedge will provide immersive exploration.

How will the visualisation contribute to your research outcomes?

The visualisation will enable researchers to compare network configurations and identify how shipment mode, facility location, inventory policy and distribution structure affect cost and service. The student will evaluate whether coordinated and immersive views improve users' ability to detect bottlenecks, interpret trade-offs and select suitable scenarios compared with conventional charts. Findings will inform future visual decision-support research.

If the project is successful, where would you consider publishing the results?

IEEE VIS or IEEE VR workshop/poster tracks; Computers & Graphics; Journal of Visualization; Decision Support Systems; or Transportation Research Part E, depending on whether the final contribution is primarily visual analytics or supply-chain decision support.

Draft Project Timeline:

Week 1

Nov 16 - Full day HIVE induction

Nov 17 - Area and Project Induction with Primary supervisor

Develop project plan with HIVE and academic team

Literature and relevant project review

Project Familiarisation

Week 2

Milestone 1: Research and simulation design Complete a focused literature review on immersive analytics, cold-chain network design and supply-chain simulation. Define the research questions, user decision tasks and evaluation measures. Specify the synthetic supply network, scenarios, assumptions, input variables and performance indicators. Present the proposed simulation and visualisation design for supervisor feedback.

Week 3

Develop the synthetic dataset and implement the initial supply-chain simulation. Model shipment movements, facility inventories, storage capacity, lead times and cost components. Create and validate baseline scenarios such as LCL versus FCL and one versus multiple cold stores. Document assumptions and test whether simulation outputs behave logically.

Week 4

Milestone 2: Functional simulation and initial visualisations Develop initial geographic, temporal, inventory and cost visualisations. Compare alternative visual encodings for facilities, shipment flows, inventory levels and storage utilisation. Build an early interactive desktop prototype and review its clarity, usability and consistency with visualisation principles.

Week 5

Integrate the simulation and visualisation components into a working scenario-comparison prototype. Add controls for shipment mode, shipment frequency, storage configuration and distribution structure. Implement performance outputs including total cost, cost per kilogram, stock availability, lead time and service level. Conduct an interim demonstration and refine the scope before the summer break.

Week 6

Milestone 3: HIVE visualisation prototype Adapt the coordinated maps, timelines, inventory profiles and performance views for the HIVE Tiled Display. Begin developing the stereoscopic space-time network visualisation for the Wedge. Work with HIVE staff to test display compatibility, interaction, readability and technical performance.

Week 7

Complete and refine the HIVE prototype. Prepare structured scenario-comparison tasks and an evaluation procedure. Conduct a small evaluation with representative users to examine whether the visualisation helps them identify bottlenecks, interpret cost-service trade-offs and compare network configurations. Record quantitative and qualitative feedback.

Week 8

Milestone 4: Evaluation findings and final prototype Analyse the evaluation results and identify the strengths and limitations of the visualisation approaches. Refine the prototype in response to user feedback. Finalise figures, screenshots, demonstration scenarios, code documentation and research findings. Prepare a clear report structure and presentation plan for Weeks 9 and 10.

Week 9

Focus on report writing and presentation (including demo) preparation

Week 10

*Focus on report writing and presentation (including demo) preparation
5th Feb Final Showcase Day and final report due*

Student Experience and Supervision:

How often will you meet with the student over the 10-week period?

One time a week, and it could be more depending on the intern

Your work desk location and the location of student desk

314.446

Student Attributes:**Please indicate any preference for student's academic discipline or field of study**

Computer Science, Software Engineering, Data Science, Information Technology, Games and Interactive Media, or a closely related discipline. Preference will be given to students with an interest in software development, simulation, data visualisation, or immersive technologies.

What competencies are required to start this project

Beginner - Game engine development (Unity, Unreal. Godot, etc.)

Beginner - Data structures, analytics, statistical modelling

Beginner - Python programming and software development. The student should have an intermediate ability to write, test, and debug Python code. Experience with data-processing libraries such as pandas or NumPy would be beneficial but is not essential.

Beginner - Data visualisation and interactive application development. Some familiarity with web-based visualisation tools, dashboards, or interactive interfaces would be beneficial. Experience with Plotly Dash, JavaScript, Unity, or similar tools is desirable but not required, as training and supervision will be provided.

Do you have any other student attributes you think are important to the project?

The student should have strong problem-solving skills, curiosity, and a willingness to learn unfamiliar technologies. They should be comfortable working with quantitative information and translating analytical results into clear interactive visualisations.

An interest in simulation, optimisation, supply chain systems, human-computer interaction, game engines, or immersive visualisation would be advantageous. The student should also be able to communicate progress clearly, seek feedback when required, work both independently and collaboratively, and maintain organised technical documentation. Prior supply chain or operations research knowledge is not required.