Vulnerability in industrial Precincts….. the coming wave

Jackie O'Dowd
Realising-Potential

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The Coming Wave

There is a lot going on and we are experiencing a world where change is relentless through geopolitical shifts, economic volatility, climate challenges, regulatory uncertainties, increasing digitisation, and complexity. Industry has a lot to contend with and none more so than industries that form part of an industrial precinct. This paper looks to explore vulnerability within industrial precincts and the challenges of not being able to see what vulnerability exists, but more importantly where it resides and the opportunities this presents.

Many things shape vulnerability. Within industrial precincts it can take many forms, which sometimes can be easy to see and understand, and at other times much less so. Vulnerability in this context can be defined as a potential weakness, a flaw or shortcoming that can exist in a process, a relationship, or at the broader precinct system level. A risk on the other hand is the potential for loss.

As we will explore, industrial precincts and vulnerability go hand in hand. An industrial precinct is often a geographically defined area that is planned and developed for industrial activity, including manufacturing, pipeline corridors alongside roads and railways, material processing, logistics, and other related operations. The precincts themselves are typically designed to support specific industry needs including access to core infrastructure such as roads, ports and utilities, and for exchanges such as gas and water through shared pipelines. Industrial precincts are particularly relevant because they can provide structured environments where companies can engage in resource sharing, waste reduction, and collaborative activity – all key aspects of industrial symbiosis. They are also complex adaptive systems meaning there is vulnerability to disruptive events, whether external or within the precinct itself.

> *"A firm's vulnerability to a disruptive event can be viewed as a combination of the likelihood of a disruption and its potential severity".*[1]

Organisations within industrial precincts are forced to address vulnerability on two fronts, from a company perspective and from an industrial precinct perspective. As Patrick Hoverstadt notes:

- "*it is the combination of the two and the dynamic that these have together that drives increasing complexity"* [2]*,* and I would add vulnerability*.*

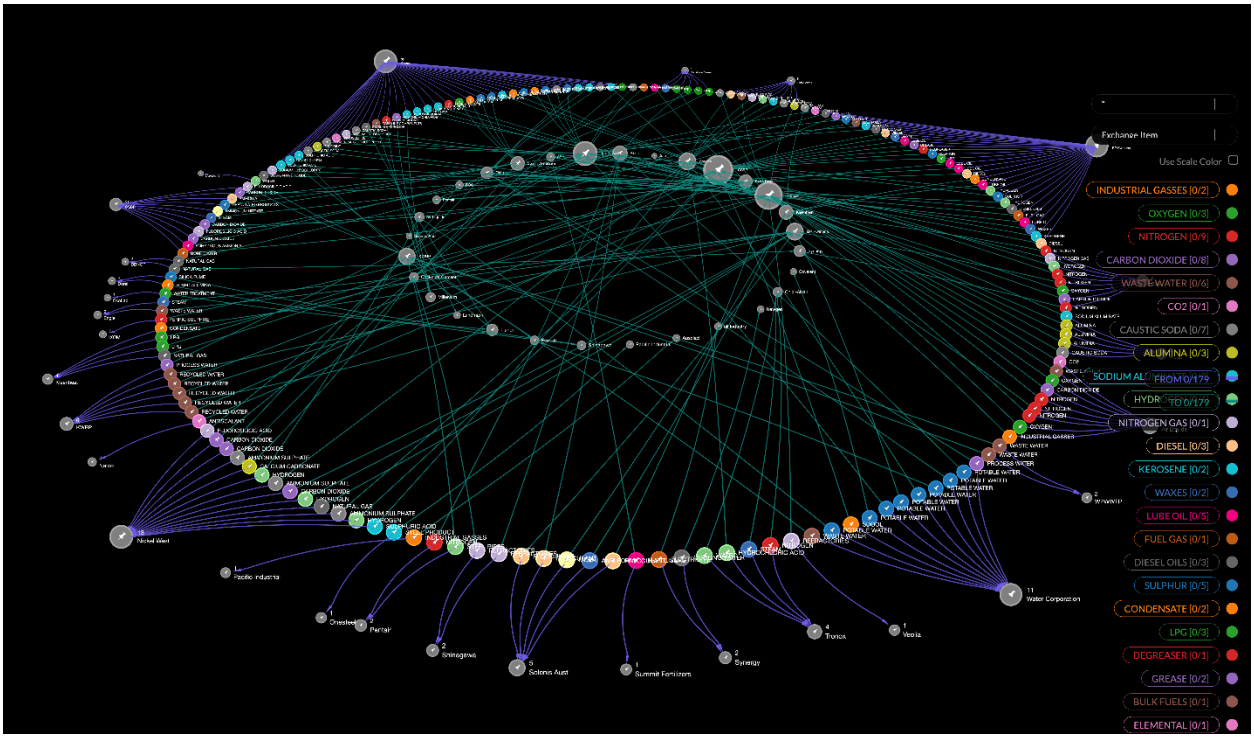
The Western Trade Coast

The Kwinana Industrial Area (KIA) in Western Australia is a great example of what can be considered a complex industrial precinct, it supports some 40,000 employees and generates revenue of ~AU$15 billion.[3]

It forms part of what is known as The Western Trade Coast (WTC), an area housing four primary industrial estates. Australian Marine Complex (AMC), Latitude 32, Kwinana Industrial Area, and the Rockingham Industry Zone. It encompasses industries such as ports, chemicals, resources, shipbuilding, manufacturing and processing. It provides an example of world class industrial clustering that leads to stronger industrial symbiosis, resource efficiency, and economic resilience.

The Western Australian Government plays a significant and essential role in the Western Trade Coast and the Kwinana Industrial Area, through its planning, infrastructure investment, regulation, and development initiatives. The funding of major infrastructure projects such as ports, rail, roads and energy is ongoing and essential. The government also works closely with training and tertiary institutions to provide research and skills training for the industrial workforce.

The Kwinana Industries Council (KIC), a non-profit Industry Association advocating for members, supports industrial symbiosis. The model below produced for Circular Ecosystems by Realising-Potential highlights the complex interweave of industries, organisations, commodities and trading relationships within the precinct. The World Economic Forum in its article *How digital collaboration is shaping the future of industrial clusters worldwide*[4] references the model and highlights that achieving large-scale collaboration within these clusters is inherently challenging without the support of strong digital capabilities to navigate complexity and optimise the integration of players within the cluster. It is through the visualisation of data that the inherent complexity and commercial relationships within the precinct becomes clear. “The Kwinana Industrial Area facilitates over 170 contracts between 54 companies for by-products exchange, encompassing water, and materials”. Kurup and Stehlik, highlight the importance and benefits of measuring both tangible and intangible benefits of industrial symbiosis.[5]



Industrial Symbiosis Model “Starship Enterprise” prepared for Circular Ecosystems

The industrial symbiosis model captures the many trade and circularity relationships in play, the commodities traded, the leverage and reuse of waste materials and the promotion of secondary markets. It highlights energy and infrastructure dependencies that need continual investment and management. Presenting data in this way allows the viewer to understand the context of the precinct, to see the level of interaction, and to explore and navigate the various economic, social, industrial, technology, infrastructure and workforce connections and dependencies that need to be enabled and supported. Within this complex interweave also comes potential vulnerability.

By visualising the construct of an industrial precinct we can see the organisations that operate within the precinct, the industry sectors they belong to, commodities traded, commercial relationships in play, and the many dependencies, constraints, vulnerabilities and risks that exist. Models such as this can provide a common and consistent vulnerability assessment. They can also shed light on shifting patterns, helping to distinguish a true vulnerability amongst the variations of normal day-to-day activities.

Vulnerability

Being able to identify points of vulnerability, dependency, and exposure, enables more proactive vulnerability and risk management and helps drive greater collaboration across industries. The insights gained from being able to visualise, analyse and navigate the available

data, helps those organisations within the precinct to better understand the context and nuance of their participation.

Having this level of visibility helps to plan for and anticipate disruption, optimise resource and material flows, and develop adaptive strategies. Being able to identify where vulnerability exists provides a baseline for opportunity, to explore where dependencies sit, how inter-precinct processes can be improved, where supply chains can be strengthened, and how a more sustainable and resilient industrial precinct can result.

We only have to look to history to understand how one vulnerability can have a much larger and broader impact. In 2008 a gas explosion on a remote North West Australian island resulted in a thirty percent reduction to the WA gas supply. Luckily no one was killed. There was a broad ripple effect through the economy losing approximately AU$3 billion. Large industrial gas users such as CSBP Fertiliser, Alcoa, and others had to resort to burning expensive diesel instead of gas. It took a year for the investigation to be completed and more than a year to resume full gas production.[6]

Vulnerabilities that appear small and inconsequential can accumulate to create major failures.

Using the KIC industrial symbiosis model we can start to identify the types of industrial vulnerabilities that exist. In the case of KIA, a key vulnerability is the tight-coupling due to the supply chain interdependencies, shared infrastructure, and material flows.

The visualisation of precinct and activity data allows the viewer to better understand the construct of the precinct and provides a valuable lens for assessing organisational and precinct vulnerability.

The complexity of industrial precincts increases the level of unpredictability, anything can fail in unpredictable ways due to the fact that vulnerabilities can arise from interaction rather than individual breakdowns or disruptions.

Regulatory changes can introduce new constraints and requirements, sometimes unintentionally, which in turn increases vulnerability and risk. Regulatory changes can also result in organisations within the precinct altering processes quickly with inadequate communication, introducing new, unforeseen, or untested interdependencies that have a ripple or flow on effect.

The following table captures a number of vulnerabilities highlighted by the industrial symbiosis model.

Activity	Vulnerabilities
Tight-Coupling	Many interconnected and tightly coupled connections
Trade and Circularity	Material and energy flows between businesses, Supply chain disruption, Precinct first supply
Shared Infrastructure	Transport, Energy, Water, Digital infrastructure, Ports, Roads, Rail, Pipelines

Workforce	Human resource availability, competencies and skills
Zoning and Planning	Land use alignment with industrial activities
Composition	Industries, Stakeholders, Service Providers, Regulatory bodies, Industry bodies, Communities
Economic	Market, Investment, Circularity
Supply Chain	Exchanges, Dependencies, Liabilities, Quality, Export fluctuations, Import fluctuations
Data and Information	Data sharing hesitancy, Data sharing agreements, Privacy, Security, Accessibility, Knowledge and insight, Naming
Climate & Environmental	Emissions, Material and Waste risks, Sustainability, Regenerative Capacity
Circularity	Supply chain complexity, Cost, Resource Loops, Feedback Loops
Assets	Renewal, Maintenance, Stranded
Regulation	Regulation, Compliance, Governance
Enterprise Architectures	Structures, Systems, Processes, Data and Information, Governance, Design, Interaction, Interoperability, Internet of Things, Complexity, Control functions
Relationships	Type, Duration, Commercial, Collaboration, Conflict, People, Locations, Organisations, Events
Materials	Types, Logistics, Handling, Contamination

Vulnerability Table

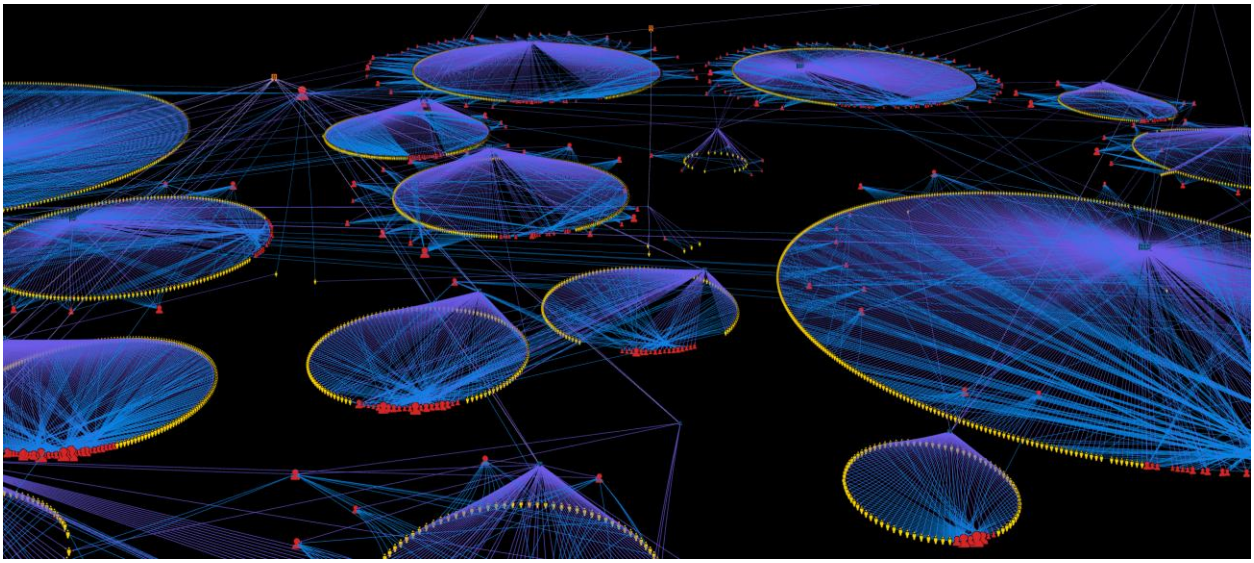
Industrial precincts fuel social and economic growth, guided by regulation and industrial strategies. “These clusters can offer economies of scale, share risks, aggregate and optimise demand. They are the connecting nodes between international markets and regional industries.”[7] This is a key reason why vulnerabilities in industrial precincts cannot be overlooked or ignored. Whilst some vulnerabilities can lead to risk, they can also lead to opportunity.

Vulnerability within industrial precincts is often perceived as a risk, but it also presents opportunities for growth, adaptation, and resilience. Regardless of the source, be it disruption exposure, supply chain shocks, policy changes, relationship breakdowns or infrastructure failures, organisations within industrial precincts are compelled to innovate. The need for redundancy in logistics, energy, by-products and raw materials can drive investment in diversified supply networks, alternative energy sources, and circular economy models. These responses can not only help reduce negative vulnerabilities but also enhance long-term efficiency and competitiveness.

Digitisation and Data Visualisation

By leveraging digital tools such as data visualisation and analytics, industrial precincts can identify potential and existing vulnerabilities by using structured, unstructured and machine and sensor data. This provides strategic and operational insights fostering greater adaptability in an evolving economic and industrial landscape. It allows each organisation to better understand the specifics of their particular complex adaptive system and position for the coming wave. Digitised models such as the ones shown, highlight how industrial precinct data

can enhance better decision-making, operational performance and collaboration across the value chain. Vulnerability assessments can provide a systemic analysis of susceptibility, and the means by which vulnerability and risk can be reduced.[8]



The 'Structures' Model

The interdependencies among companies within industrial precincts creates opportunities for symbiotic relationships, where by-products from one process becomes an input for another, enhancing sustainability and reducing costs as can be seen by the KIC example. Regulatory challenges, whilst often viewed as constraints, can push companies toward compliance-driven innovation, leading to the adoption of cleaner technologies as well as more resilient operational models. By recognising vulnerability as a dynamic force, industrial precincts can position themselves to not only withstand challenges but to thrive through proactive transformation and strengthened regional economic integration.

Every organisation is vulnerable. For some it materialises through avoidance and defensiveness, and/or structural and operational behaviours. In others it can materialise through rigid controls, internal conflicts, dismissing industry trends, or simply by the complexity of precinct and commercial relationships themselves. Additionally, some vulnerabilities materialise simply because we don't see or acknowledge them.

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About the Author

Jackie O'Dowd is the Founding Partner and CEO of Realising-Potential, based in Perth Western Australia. With a Master's in Leadership and Management from Curtin University, she advises and consults across multiple sectors, including manufacturing, petroleum, government, health, mining, and civil construction. She assists executive and leadership teams to remediate complex projects, improve and optimise organisational insight and business architectures and provides expert opinion for organisations that have legal disputes to settle or questions to answer.