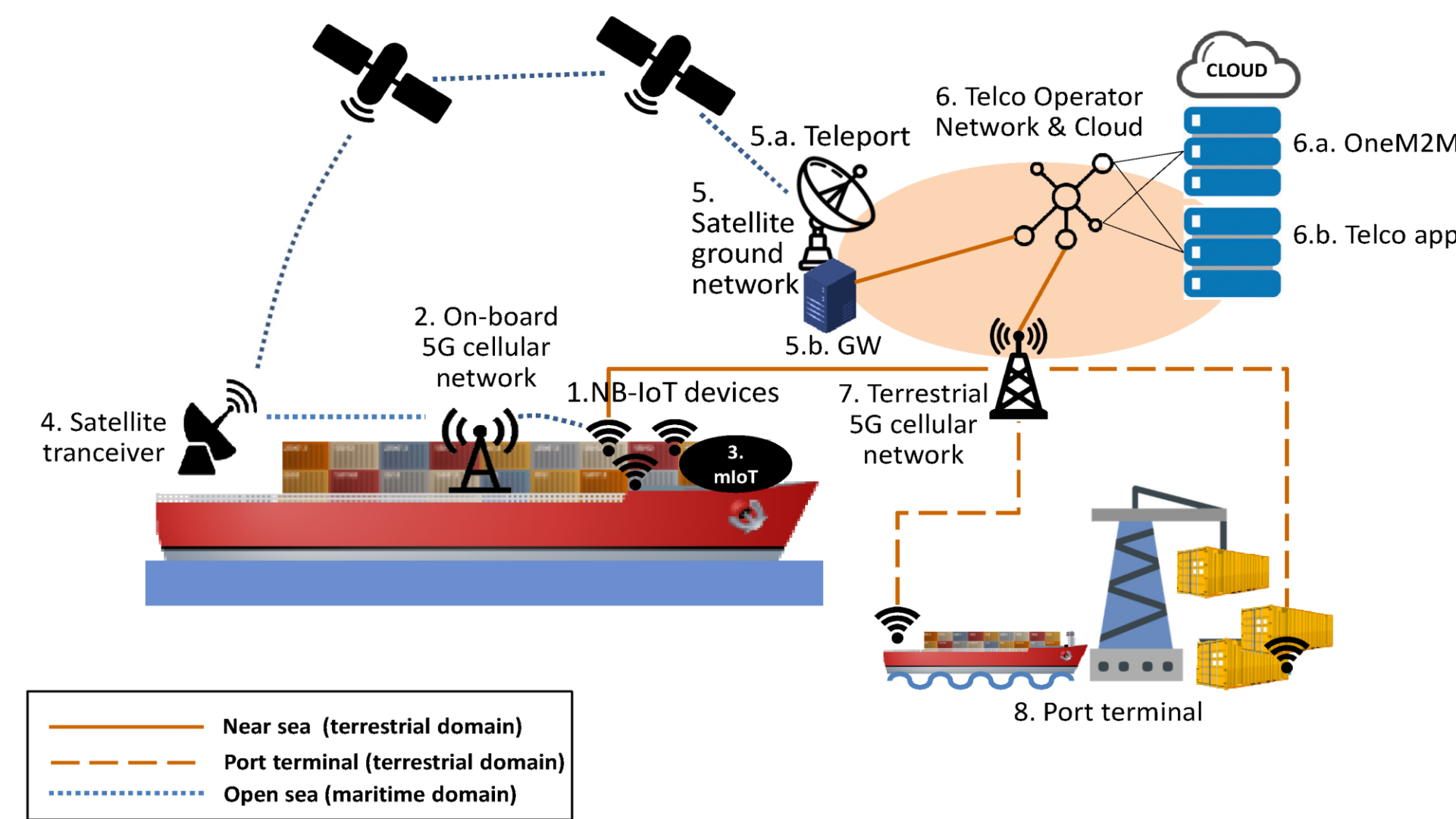


Abstract

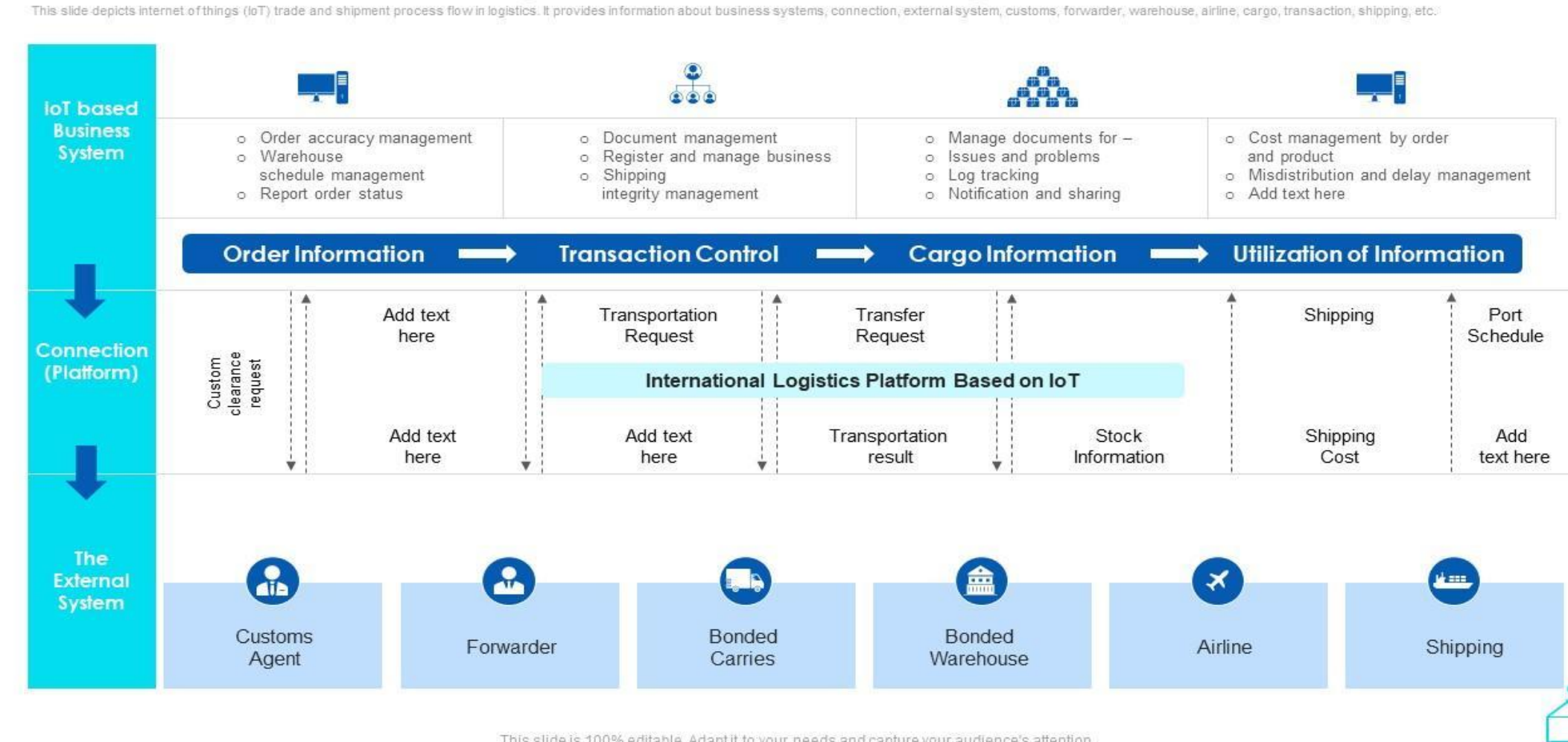
The transportation of hazardous oilfield materials such as crude oil, natural gas liquids, and petroleum-based chemicals requires strict safety and compliance. Intermodal systems involving pipelines, trucks, railcars, and ships add complexity, as each mode carries unique risks and regulations. Transfers between modes further increase the chance of incidents and demand precise coordination. The Internet of Things (IoT) improves safety and oversight by providing real-time monitoring of cargo conditions, location, and handling. Sensors track factors like temperature, pressure, and movement, sending alerts when issues arise, even in remote areas. Combined with blockchain, IoT creates secure, verifiable records that enhance transparency and regulatory compliance. This study explores how IoT improves safety, visibility, and coordination in the intermodal transport of hazardous oilfield cargo.



(Image 1) Appl. Syst. Innov. 2023, 6(3), 58

A technical visualization showing IoT devices (including NB-IoT, 5G, and satellite links) integrated across maritime and land transport systems. This diagram effectively illustrates real-time cargo tracking and connectivity across port-to-port logistics.

IoT Trade and Shipping Process Flow in Logistics



(Image 2) SlideTeam. (n.d.). IoT trade and shipping process flow in logistics

IoT in Oil & Gas Uses sensors, predictive analytics, and smart devices for real-time monitoring of pipelines, fleets, assets, and operations—boosting safety, efficiency, and maintenance while reducing risks and downtime.

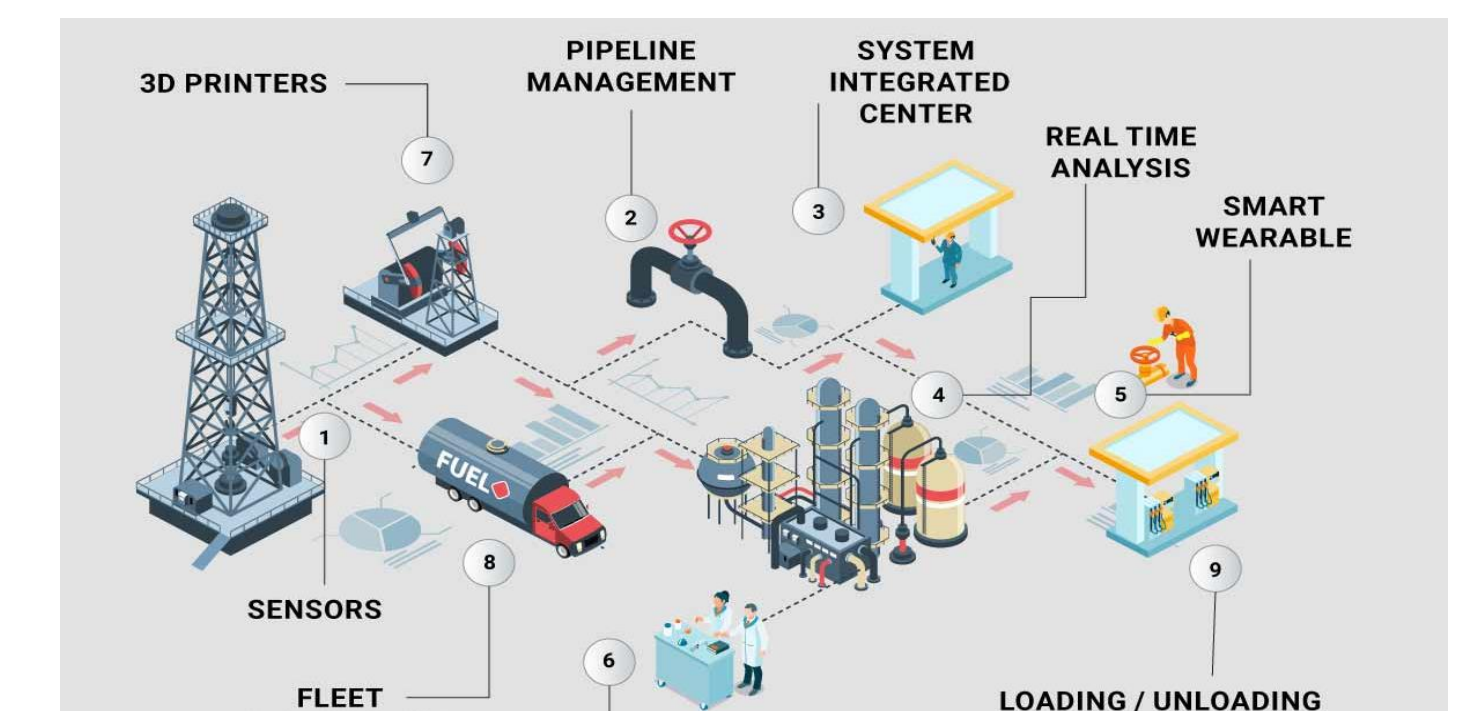
Real-Time Coordination & Data Integrity

Effective intermodal transport relies on timely information sharing among stakeholders. IoT platforms consolidate data from all transport modes into centralized dashboards for logistics operators, carriers, regulators, and cargo owners. Predictive routing tools use this data with traffic, weather, and infrastructure conditions to optimize shipment paths. Blockchain complements IoT by providing immutable records of cargo handling, condition reports, and custody transfers, preventing data manipulation, reducing disputes, and streamlining regulatory reporting to agencies like the DOT, PHMSA, and IMO. Together, IoT and blockchain enhance operational reliability, environmental protection, and audit readiness.

Intermodal Risks and IoT Solutions

Hazardous material transport carries mode-specific risks: pipelines may leak or corrode; trucks face accidents and route changes; railcars can derail or endure structural stress; maritime transport contends with storms, navigation hazards, and port delays. These risks are heightened during modal transfers. IoT helps manage these risks by monitoring cargo conditions with sensors, tracking locations via GPS and geofencing, and transmitting data through LoRaWAN, 5G, or satellite links. Edge computing processes data on-site for faster responses, improving situational awareness and reducing time between detection and corrective action.

References



(Image 3) Rishabh Software. (2023, June 29). IoT in oil and gas sector

Conclusion

IoT is redefining the management of hazardous oilfield materials in intermodal transport by integrating continuous monitoring, predictive analytics, and secure recordkeeping. These capabilities improve safety performance, enable faster incident response, and ensure regulatory compliance across pipelines, highways, rail networks, and maritime routes. As industry standards evolve and regulatory demands increase, IoT will play a central role in building safer, more efficient, and more resilient supply chains for high-risk cargo.

Smart Cargo, Safer Routes: LoT Transport of Hazardous Oilfield

Malak Alamar & Sayma El Hoderi

Faculty Advisor: Margaret Kidd

University of Houston

Industry Advisor: Margaret Kidd

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