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A heuristic framework for pod scheduling with empty carrier movement

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Amid the growing need for more sustainable freight transport, the rail sector faces challenges in competing with road transport due to lower flexibility and reliability. To address these challenges, intermodal rail freight systems must evolve to enhance flexibility and integrate more seamlessly with broader mobility services. A key factor in the success of such innovations is the integration with existing railway infrastructure. This study examines the concept of modular vehicles (MVs) in rail systems, focusing on the innovative 'Pod' system developed in the Pods4Rail project. These Pods consist of detachable flat wagons (carriers) and capsules or containers (transport units) capable of moving both goods and passengers. A fundamental requirement for MVs is the assignment of carriers to transport units, allowing them to operate on the rail network. This involves , ensuring the availability of carriers at pickup points in terms of assignments of carriers to transport units as well as relocating empty carriers across the network. This may lead to empty runs and potential capacity challenges. Once assigned, complete Pod formation (combinations of carriers and transport units) form swarms or platoons through virtual coupling, which could significantly improve capacity utilization. This paper presents a heuristic framework that incorporates the assignment of carriers to transport units, and pod dispatching for pickup and delivery, including empty carrier circulation, considering parameters for the operation in virtual coupling. Results indicate that platooning reduces makespan for larger problem sizes, but requires a sufficient number of carriers.