Annex A

Coning/deconing operations

Background	Container fittings—such as twistlocks, midlocks, or cones—are used to secure the four corners of containers when they are stacked. Currently, stevedores must manually fix or remove these fittings during loading and discharging operations, often working under hazardous conditions. This process, known as 'coning' and 'deconing,' typically takes place at the interface between quay cranes and horizontal transport vehicles. **Coning/Deconing:**
Present state	Coning and deconing operations at the wharf remain manual, requiring stevedores to work in close proximity to suspended loads and active horizontal transport. Typically, two workers are deployed per crane to handle container fittings during loading and unloading. As containers are discharged, workers must fix or remove fittings at each corner, with each worker responsible for two ends of the container per cycle. This process is further complicated by the manual retrieval of fittings from gear bins, which often contain a disorganized mixture of different models. Despite existing efforts to automate coning/deconing, the industry lacks a comprehensive solution capable of full automation. The critical challenge

lies in the lack of standardization: more than 100 types of container fittings exist, and vessels often arrive with unpredictable combinations. This 'high-mix' environment creates substantial barriers for automated equipment, which must be able to identify and manipulate a wide array of hardware with high precision.

Coning/Deconing operating concept at the wharf side:

General workflow for de-coning ops as follows:

1. Quay Crane spreader discharges the container from the vessel
2. Containers are loaded onto the trailer
3. Stevedores perform coning at the wharf side to secure the container to the trailer
4. Containers are transported to the yard by the trailer
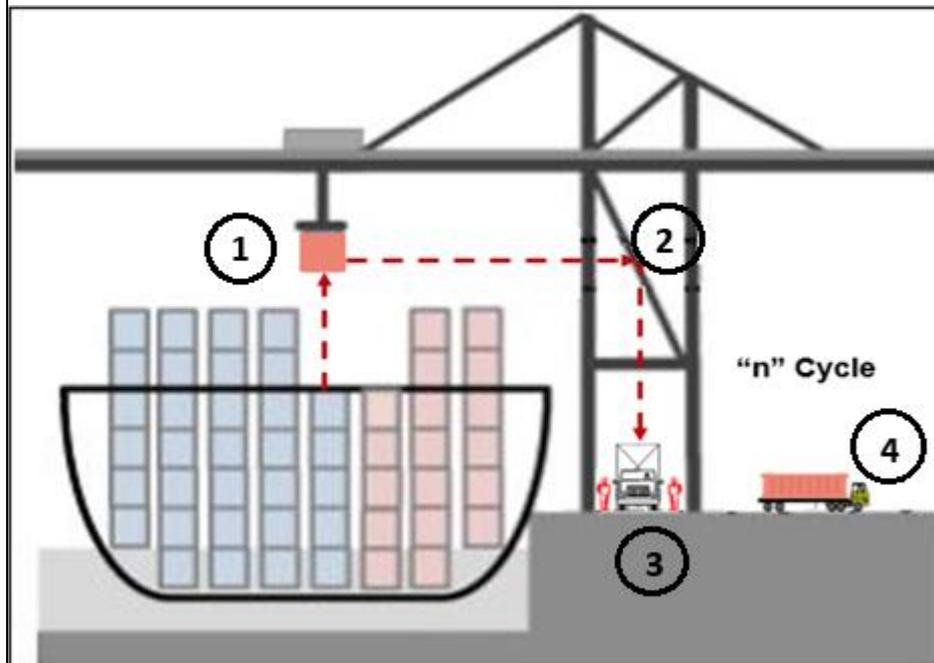
Container fittings consists of namely:

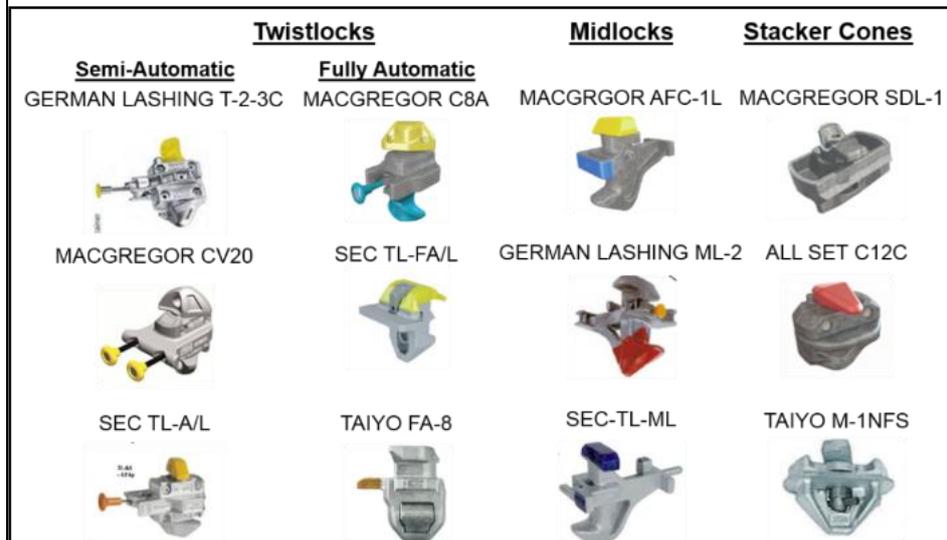|	
	a. Twistlock: Two types, i.e. Semi-Automatic and Fully Automatic are available in the market. The purpose is to lock the containers that are stacked on top of one another above deck **b.** Midlock: Applicable for 2 x 20ft containers, to lock on the inner end of the corner castings; where lashing of the containers is not accessible. Whereas, at the outer end of the corner casting, twistlocks are still being used. **c.** Stacker Cone: Used only below deck, as the containers are stacked within cell guides. The main purpose is to align the containers in place. **Examples of Container Fittings are shown in the figure below.**
Lesson Learnt	SMI funded 1 project related to wharf-side coning / deconing. This project developed a mobile robotic solution equipped with soft-gripper robotic arms to perform coning and deconing operations *at the wharf side*. While the concept demonstrated robustness in mobility, the soft-gripper design was not sufficiently durable to withstand the harsh operating

environment. In addition, the absence of embodied AI capabilities limited the efficiency of twistlock identification and locking operations.

For awareness of other relevant SMI funded projects:

Project A to address Vessel ops:

Project A developed a combined solution comprising a multi-legged robotic platform and newly designed electric-powered remote-controlled and autonomous twistlocks deployed *on board the vessel*. Experimental results indicated low deployment efficiency when using the multi-legged robot for autonomous twistlock installation, highlighting limitations in operational practicality.

Project B to address Quay Crane ops for Vessel Ops:

Project B developed an innovative approach in which robotic arms were mounted *onto a quay crane spreader* to perform coning and deconing operations at the *vessel side*. However, due to space constraints and integration limitations on the spreader, the solution was assessed to require further developments before practical adoption.