Summary

[004a] In an aspect, the present disclosure refers to a method for delivering items to a storage assembly having a plurality of storage locations, comprising the steps of:

providing a delivery mechanism movable along a path encompassing an input station and a target storage location of the plurality of storage locations, wherein the delivery mechanism includes

a support defining a carrying surface dimensioned and arranged to receive an item to be delivered and to support the item to be delivered as the delivery mechanism moves along the path,

a first wall extending along a first side of the carrying surface, and

a second wall extending along a second side of the carrying surface and opposing the first wall so that a first transfer passage is formed proximate a first end of the support and a second transfer passage is formed proximate a second end of the support,

wherein the delivery mechanism further includes a retention assistant comprising a displaceable wall dimensioned and arranged to extend transversely relative to the first and second walls, the displaceable wall being displaceable between a first position preventing an item to be delivered from moving into the first transfer passage and a second position permitting movement of an item to be delivered into and through the first transfer passage;

moving the delivery mechanism with a first item to be delivered along a path to a position proximate a first target storage location;

displacing the displaceable wall from the first position to the second position; and

transferring the first item from the delivery mechanism to the first storage location after the step of moving the delivery mechanism.

[004b] In an aspect, the present disclosure refers to a delivery vehicle operable with a material handling system having a plurality of storage locations and a gate opening mechanism adjacent one of the storage locations, wherein the delivery vehicle comprises:

a drive system for driving the vehicle to one of the destination areas;

a motor for driving the drive system;

a transfer mechanism for transferring items between the vehicle and the storage locations wherein the transfer mechanism comprises a surface for receiving an item to be conveyed to one of the storage locations;

a pair of opposing walls extending upwardly relative to the surface and spaced apart from one another so that at least a portion of the surface is between the opposing walls, wherein the opposing walls are dimensioned and arranged to facilitate transfer of items off the surface at a first end of the surface and to facilitate transfer of items off the surface at a second end of the surface;

a first gate positioned adjacent the first end of the surface and operable between an opened position and a closed position, wherein in the closed position the first gate extends across the first transfer passage and operates as a stop to impede displacement of items off the surface at the first end and in the opened position the first gate allows displacement of items off the surface at the first end;

a first actuator connected with the first gate and operable between a first position in which the first gate is in the closed position and a second position in which the first gate is in the opened position wherein the first actuator is configured to cooperate with the gate opening mechanism so that displacement of the delivery vehicle relative to the gate opening mechanism is operable to displace the first actuator into the second position.

[004c] In an aspect, the present disclosure refers to a material handling system, comprising

a plurality of storage locations;

a first actuator adjacent one of the storage locations;

a plurality of delivery vehicles, wherein a first of the delivery vehicles comprises:

a motor for driving the delivery first vehicle;

a transfer mechanism for transferring items between the first vehicle and the storage locations wherein the transfer mechanism comprises a surface for receiving an item to be conveyed to one of the storage locations;

a pair of opposing walls extending upwardly relative to the surface and spaced apart from one another so that at least a portion of the surface is between the opposing walls, wherein the opposing walls are dimensioned and arranged to facilitate transfer of items off the surface at a first end of the surface and to facilitate transfer of items off the surface at a second end of the surface;

a first gate positioned adjacent the first end of the surface and operable between an opened position and a closed position, wherein in the closed position the first gate extends across the first transfer passage and operates as a stop to impede displacement of items off the surface at the first end and in the opened position the first gate allows displacement of items off the surface at the first end;

a second actuator connected with the first gate and operable between a first position in which the first gate is in the closed position and a second position in which the first gate is in the opened position wherein the second actuator is configured to cooperate with the first actuator so that displacement of the delivery vehicle relative to the first actuator is operable to displace the second actuator into the second position.

[004d] In an aspect, the present disclosure refers to a material handling system, comprising:

a plurality of storage locations;

an input station;

a plurality of delivery mechanisms each being dimensioned and arranged to receive an item at the input station and each being movable along a path encompassing the input station and a corresponding target storage location of the plurality of storage locations;

wherein each delivery mechanism includes

a transfer mechanism defining a carrying surface dimensioned and arranged to receive an item to be delivered from the transfer station and to support the item to be delivered as the delivery mechanism moves along a respective path to a corresponding target storage location,

a first wall extending along a first side of the carrying surface, and

a second wall extending along a second side of the carrying surface and opposing the first wall so that a first transfer passage is formed proximate a first end of the support and a second transfer passage is formed proximate a second end of the support,

a retention assistant comprising a displaceable wall dimensioned and arranged to extend transversely relative to the first and second walls, the displaceable wall being displaceable between a first position preventing an item to be delivered from moving into the first discharge opening and a second position permitting movement of an item to be delivered into and through the first discharge opening, wherein the displaceable wall is one of displaceable with or displaceable relative to the carrying surface; and

a motor controllable to transfer the first item from the carrying surface of the transfer mechanism to the first storage location while the displaceable wall is in the second position.

[004e] In an aspect, the present disclosure refers to a method for transporting an item upon a carrying surface of a delivery mechanism, the carrying surface defining a retention zone bounded by first and second lateral walls and first and second retention assistant walls,

wherein the first and second walls respectively define corresponding lateral wall

surfaces disposed transverse to a direction of delivery mechanism travel along a path extending from an input station to a target storage location, each of the lateral wall surfaces being oriented to impede lateral movement of an item out of the retention zone,

wherein the first retention assistant wall is disposed transverse to the first and second lateral wall surfaces and is displaceable from a first position impeding movement of an item out of the retention zone to a second position enabling movement of an item out of the retention zone and in a first transfer direction: and

wherein the second retention assistant wall is disposed transverse to the first and second lateral wall surfaces, is spaced apart from the first retention assistant wall, and is one of non-manipulable out of a position impeding movement of an item out of the retention zone or displaceable from a first position impeding movement of an item out of the retention zone to a second position enabling movement of an item out of the retention zone and in a second transfer direction opposite the first transfer direction; the method comprising

at the input station, positioning an item within the retention zone and onto the carrying surface of the delivery mechanism;

while the first and second retention assistant walls are disposed in positions which impede movement of the positioned item out of the retention zone, advancing the delivery mechanism from the input station and along the path while the positioned item is free to move upon the carrying surface and within the boundaries of the retention zone despite changes in at least one of delivery mechanism direction of travel or delivery mechanism rate of travel;

from a position proximate a target storage location along the path, displacing the second retention assistant wall from the first position to the second position and operating a transfer mechanism of the delivery mechanism to move the item in the first transfer direction, out of the retention zone, and into the target storage location.

[004f] In an aspect, the present disclosure refers to a material handling system, comprising:

a plurality of storage locations;

an input station;

a plurality of mobile delivery mechanisms each being dimensioned and arranged to receive an item at the input station and each being movable along paths encompassing the input station and a corresponding target storage location of the plurality of storage locations; and

a controller for controlling movements of the mobile delivery mechanisms along paths adjacent to the plurality of storage locations;

wherein each delivery mechanism includes

a transfer mechanism defining a carrying surface dimensioned and arranged to receive an item to be delivered at the station and to support the item to be delivered as the delivery mechanism moves along a respective path to a corresponding target storage location,

a first lateral wall extending along a first side of the carrying surface, and

a second lateral wall extending along a second side of the carrying surface and opposing the first wall so that a first transfer passage is formed proximate a first end of the support and a second transfer passage is formed proximate a second end of the support,

a retention assistant comprising a first retention assistant wall and a second retention assistant wall,

the first retention assistant wall being dimensioned and arranged to extend transversely relative to the first and second lateral walls and displaceable between a first position substantially closing the first transfer passage to thereby prevent an item on the carrying surface from moving into and through the first transfer passage and a second position permitting movement of an item to be delivered into and through the first discharge opening, and

the second retention assistant wall being disposed transverse to the first and second lateral wall surfaces, spaced apart from the first retention assistant wall, and being one of non-manipulable out of a position impeding movement of an item out of the retention zone or displaceable from a first position substantially closing the second transfer passage to thereby prevent an item on the carrying surface from moving into and through the second transfer passage to a second position; and

a motor controllable to transfer a first item from the carrying surface of the transfer

mechanism to the first storage location while the first retention assistant wall is in the second position.

[005] The aforementioned need is addressed, and an advance is made in the art, by systems and methods capable of sustaining a high level of item processing throughput by enhancing the retention of respective items as they are transported by corresponding mobile delivery mechanisms. In examples, irregularly shaped items such, for example, as those having a cross sectional profile characterized by arcuate surface portions (e.g., cylindrically or spherically shaped items) are free -- during movement of the delivery mechanisms along an item delivery path path – to move upon a carrying surface of the delivery mechanism, but such movement is constrained to the boundaries of a defeatable retention zone despite changes in the direction and/or velocity of the delivery mechanism. When intact, the defeatable retention zone is bounded by first and second spaced apart lateral side walls of the delivery mechanism and first and second spaced apart retention assistant walls. The retention zone is defeatable in the sense that at least one of the retention assistant walls is displaceable such that it/they can be moved from a first position which extends transversely relative to the lateral side walls to close off a corresponding transfer passage through which an item could otherwise escape the retention zone and a second position which temporarily removes an applicable retention assistant wall as a boundary of the retention zone.

[006] In a first example, each of one or more retention assistant walls of a delivery mechanism are configured as one or more pivotably movable door(s) (or gates) which are displaceable, relative to a carrying surface of the delivery mechanism, by pivoting from a first position -- in which a door is disposed across an item transfer passage to thereby form a boundary of the retention zone to impede movement of an item through the item transfer passage and out of the retention zone – to a second position in which the door is no longer disposed across the item transfer passage and an item being carried by the delivery mechanism is thereafter able to pass through the transfer passage, out of the retention zone, and into a storage location.

[007] In a second example, first and second retention assistant walls of a delivery mechanism are configured as first and second spaced apart cleats which are

transversely disposed across an item carrying surface portion of an endless conveyor belt and which are displaceable by pivoting from a first position -- in which a door is disposed across an item transfer passage to thereby form a boundary of the retention zone to impede movement of an item through the item transfer passage and out of the retention zone – to a second position in which the door is no longer disposed across the item transfer passage so that the item is able to pass through the transfer passage, out of the retention zone, and into a storage location.

[008] In examples, a method for sorting items by delivery to target storage locations of a plurality of storage locations, an item is positioned upon the carrying surface of a delivery mechanism, the carrying surface defining a retention zone bounded by a first lateral wall, a second lateral wall, a first retention assistant (or third) wall, and a second retention assistant (or fourth) wall. At least one of the first retention assistant wall or the second retention assistant wall is/are displaceable to define a transfer passage (e.g., a channel or opening) proximate a corresponding side of the retention zone, the transfer passage being dimensioned and arranged to allow movement of an item out of the retention zone subsequent to displacement of a corresponding retention assistant wall. The delivery mechanism, which in some examples is configured as a delivery vehicle, moves along a path from the location where an item is received upon the carrying surface (e.g., an input station) to a location proximate the target storage location to facilitate transfer of the item through the opening obtained by displacing one of the first retention assistant wall or the second retention assistant wall.

[009] In one or more examples, a method for delivering items to a storage assembly having a plurality of storage locations comprises: providing a delivery mechanism movable along a path encompassing an input station -- where an item to be delivered is received -- and a target storage location of the plurality of storage locations. The delivery mechanism includes (a) a support defining a carrying surface dimensioned and arranged to receive an item to be delivered and to support the item to be delivered as the delivery mechanism moves along the path, (b) a first wall extending along a first side of the carrying surface, and (c) a second wall extending along a second side of the carrying surface and opposing the first wall so that a first transfer passage (or channel) is

formed proximate a first end of the support and a second transfer passage (or channel) is formed proximate a second end of the support.

[010] In examples, the delivery mechanism provided during the providing step further includes a retention assistant comprising a displaceable wall dimensioned and arranged proximate a first end of the support to extend transversely relative to the first and second walls, the displaceable wall being displaceable from a first position, wherein an item disposed on the carrying surface and unrestrained is blocked from passing through the first transfer passage, into a second position wherein the unrestrained item is no longer blocked and therefore free to pass through the first transfer passage. According to such examples, the method further includes moving the delivery mechanism, together with a first item to be delivered, along a path to a position proximate a first target storage location; displacing the displaceable wall of the retention assistant from the first position to the second position; and transferring the first item from the delivery mechanism to the first storage location after moving the delivery mechanism.

[011] Optionally, the retention assistant of the provided delivery mechanism is a first retention assistant having a first displaceable wall that is displaceable into the first position and the second position, and wherein the provided delivery mechanism further comprises a second retention assistant having a second displaceable wall dimensioned and arranged proximate a second end of the support to extend transversely relative to the first and second walls, the second displaceable wall being displaceable between a third position preventing an unrestrained item disposed on the carrying surface from moving into and through the second transfer passage and a fourth position permitting an item disposed on the carrying surface to pass into and through the second transfer passage, and the method further including moving the delivery mechanism with a second item to be delivered along a second path to a position proximate a second target storage location; displacing the second displaceable wall from the third position to the fourth position; and transferring the second item from the delivery mechanism to the second target storage location after the step of moving the delivery mechanism.

[012] In a first example, the displaceable wall of the first retention assistant is a first door adjacent the first end and displaceable between a closed position in which the door extends across the first transfer passage to impede transfer of items

through the first transfer passage and an open position in which the first door is displaced away from the first transfer passage to permit transfer of items through the first transfer passage; wherein the first retention assistant further includes a first actuator connected with the first door to displace the door between the closed and opened positions; wherein moving the delivery mechanism with a first item to be delivered along a path to a position proximate a first target storage location includes moving the delivery mechanism toward a second actuator so that the first actuator engages the second actuator to displace the first door into the open position; and wherein transferring the first item from the delivery mechanism to the first storage location is performed after moving the delivery mechanism toward a second actuator.

[013] Optionally, or in addition, the method of the example further comprises a step of moving the delivery mechanism from the first storage location to disengage the first actuator from the second actuator. Optionally, or in addition, the method of the example further comprises a step of displacing the first door into the closed position in response to the step of disengaging the first actuator from the second actuator. Optionally, or in addition, the delivery mechanism comprises a biasing element biasing the first door toward the closed position and wherein the step of displacing the first door into the closed position comprises releasing the door so that the biasing element displaces the door toward the closed position, and moving the delivery mechanism toward a second actuator comprises displacing the first actuator against the bias of the biasing element.

[014] In any and all of the foregoing variations of the first example, the delivery mechanism provided and used may be implemented as a delivery vehicle, the method in such cases further including driving the delivery vehicle toward a loading station; and driving the first actuator toward a third actuator adjacent the loading station to displace the first actuator into engagement with the third actuator to open the first door.

[015] In a second example, the support of the provided delivery mechanism includes a pair of rollers and a transfer conveyor trained around the rollers, wherein the first and second displaceable walls are cleats disposed transversely across the transfer conveyor at a spacing sufficient to accommodate receipt of an item therebetween and retention of the received item between the first and second cleats as

the delivery mechanism moves toward a target storage location, the method comprising controlling movement of the transfer conveyor.

[016] In a first variation of a method according to the second example, a third cleat is included between the first and second cleats of the delivery mechanism, wherein the first and third cleat are spaced apart sufficiently to define a first retention zone for receiving a first item, and wherein the second and third cleat are spaced apart sufficiently to define a second retention zone for receiving a second item, the method including receiving a first item in the first retention zone and a second item in the second retention zone.

[017] In a second variation of a method according the second example, the method further including controlling movement of the transfer conveyor so that the first cleat is displaced into the second position; operating the feed conveyor and transfer conveyor to pass an item from the feed conveyor, through the first transfer passage, and onto the transfer conveyor of the delivery mechanism; and continuing to controlling operation of the transfer conveyor so that the first cleat is displaced into the first position.

[018] Optionally, or in addition, a method according to the second variation further includes controlling movement of the delivery mechanism along a path to a target storage location of a plurality of storage locations, controlling the transfer conveyor of the delivery mechanism to move the first cleat into the second position, and operating the transfer initiating movement of the delivery mechanism to the first storage location after the step of moving the delivery mechanism.

[019] A material handling system according to a further example consistent with the present disclosure comprises: a plurality of storage locations; an input station; a plurality of mobile delivery mechanisms each being dimensioned and arranged to receive an item at the input station and each being movable along paths encompassing the input station and a corresponding target storage location of the plurality of storage locations; and a controller for controlling movements of the mobile delivery mechanisms along paths adjacent to the plurality of storage locations; wherein each delivery mechanism includes a transfer mechanism defining a carrying surface dimensioned and arranged to receive an item to be delivered at the station and to support the item to be delivered as the delivery

mechanism moves along a respective path to a corresponding target storage location, a first lateral wall extending along a first side of the carrying surface, and a second lateral wall extending along a second side of the carrying surface and opposing the first wall so that a first transfer passage is formed proximate a first end of the support and a second transfer passage is formed proximate a second end of the support.

[020] Delivery mechanisms of the plurality of delivery mechanisms further include a retention assistant comprising a first retention assistant wall and a second retention assistant wall, wherein the first retention assistant wall is dimensioned and arranged to extend transversely relative to the first and second lateral walls and is displaceable between a first position substantially closing the first transfer passage to thereby prevent an item on the carrying surface from moving into and through the first transfer passage and a second position permitting movement of an item to be delivered into and through the first transfer passage and into a target storage location.

[021] In some examples of the material handling system, the second retention assistant wall is disposed transverse to the first and second lateral wall surfaces, is spaced apart from the first retention assistant wall, and is not manipulable out of a position impeding movement of an item through the second transfer passage and out of the retention zone. In other examples of the material handling division, the second retention assistant wall is displaceable from a first position substantially closing the second transfer passage -- to thereby prevent an item on the carrying surface from moving into and through the second transfer passage -- to a second position permitting movement of an item to be delivered into and through the second transfer passage and into a target storage location.

[022] In any of the foregoing material handling system examples, each delivery mechanism may include a motor controllable to transfer a first item from the carrying surface of the transfer mechanism to a first storage location while the first retention assistant wall is in the second position. In some examples, each mobile delivery mechanism is a delivery vehicle, wherein the motor of each delivery vehicle is a first motor and wherein the delivery vehicle further includes a second motor operative to drive the delivery vehicle along a path from the input station to a target delivery location, and wherein the first and second lateral walls and the retention assistant are dimensioned

and arranged such that an item disposed on the carrier surface of the delivery vehicle is free to move upon the carrying surface but is confined to the boundaries of the retention zone despite changes in at least one of delivery vehicle direction of travel or delivery vehicle rate of travel.

[023] In some examples where each delivery mechanism is a delivery vehicle, each path traveled by a delivery vehicle of the plurality of delivery vehicles is a vertical loop path which encompasses a position proximate the input station and a position proximate a target storage location of a plurality of storage locations, wherein the input station includes an feed conveyor operatable to feed items to the delivery mechanism, wherein the second retention assistant wall is displaceable from the first position to a second position permitting movement of an item to be delivered into and through the second transfer passage, and wherein the first motor is further controllable to transfer an item out of the retention zone and into a target storage location while the second retention assistant wall is in the second position.

[024] In examples, the transfer mechanism of each delivery vehicle includes an endless belt looped around a pair of rollers, wherein the retention zone is defined by an upwardly facing surface portion of the endless belt, and wherein the first motor is controllable to advance the endless belt in at least one of the first transfer direction or the second transfer direction such that a retention zone portion of the endless belt is circumscribed by surfaces of the first and second lateral walls and first and second retention assistant walls. In one such example, the first and second retention assistant walls are defined by first and second elongated cleats which are separated from one another by a distance sufficient to circumscribe, with the lateral wall surfaces, the item retention zone, wherein displacement of the first retention assistant wall into the first position includes actuating the first motor to advance the endless belt such that the first and second elongated cleats are upwardly facing. In some examples, the first and second retention assistant walls define surfaces which extend from the carrying surface of the endless belt by a distance of from about 0.5 cm to about 3.75 cm.

[025]In accordance with some examples, the first and second retention assistant walls define surfaces which are substantially orthogonal to a plane defined by a portion of the carrying surface and in other examples, the first and second retention