CLAIMS

1. A system arranged to control movement of one or more transporting devices said transporting devices arranged to transport containers, said containers being stored in a facility, in which the facility is arranged to store the containers in a plurality of stacks, the facility further having a plurality of pathways arranged in a grid-like structure above the stacks, the one or more transporting devices arranged to operate on the grid-like structure, the system comprising:

one or more computers configured to execute computer instructions which when executed provide:

one or more utilities arranged to determine and reserve routes for moving the one or more transporting devices through the plurality of pathways and determine and reserve routes for moving the one or more transporting devices when transporting one or more of the plurality of containers; and

one or more utilities arranged to determine and control retrieval of the one or more containers by the one or more transporting devices from within one or more of the plurality of stacks, wherein retrieval of the one or more containers from within the one or more stacks further requires moving one or more other containers in the stack prior to accessing the one or more containers for retrieval,

wherein the utilities together are arranged to control retrieval and movement of the one or more containers once retrieved by the or each transporting device, said utilities being further arranged to instruct one or more of the transporting devices to move one or more containers from within one or more stacks to an alternative position within the facility,

the system further comprising a product placement optimisation means arranged to determine the alternative position from an available pool of empty locations within any one of the stacks other than the stack from which the or each container was removed.

2. A system according to claim 1, wherein the product placement optimisation means is further arranged to determine the alternative position by scoring, with a configurable, weighted cost function, each stack location based on the average distance from all workstations, distance from a closest workstation and an approximate dig cost.

3. A system according to claim 2, wherein the product placement optimisation means is further arranged to determine the alternative position based on a difference

between the scoring of the configurable, weighted cost function and the length of a path from a source to the stack location and for how long the stack is reserved.

4. A system according to claim 2 or claim 3, wherein the product placement optimisation means is further arranged to determine the alternative position based on at least one of: the total weight of the stack, and controlling the position of hazardous or special substances.

5. A system according to any of claims 1 to 4, wherein the product placement optimisation means is further arranged to determine the alternative position based on at least one of: the layout of the grid-like structure, the frequency at which a particular item is requested, future ordering, predicted future ordering, the location of workstations, the location of charging stations, and the congestion level of particular areas and branches of the pathway.

6. A system according to any preceding claim in which the alternative position may comprise a location external to any stack but within the facility.

7. A system according to any preceding claim in which the or each of the containers contain objects, the objects being stored in the containers in the stacks for subsequent retrieval.

8. A system according to any preceding claim comprising one or more further utilities providing a clearance system for permitting or stopping movement of the one or more transporting devices to avoid collisions.

9. A system according to any preceding claim comprising one or more further utilities comprising optimizing means configured to optimise the movement and actions of the one or more transporting devices through the plurality of pathways.

10. A system according to claim 9 said optimising means comprising placing means configured to optimise the placement of the plurality of containers by the one or more transporting devices in the facility.

11. A system according to claim 9 or claim 10, wherein any one of the utilities that optimise the movement and actions of any one of the transporting devices use one or more path finding algorithms.

12. A system according to claim 9 or claim 10, wherein any one of the utilities that optimise the movement and actions of any one of the transporting devices use one or more congestion mitigation techniques.

13. A system according to claim 9 or claim 10, wherein any one of the utilities that optimise the movement and actions of any one of the transporting devices use one or more machine learning techniques.

14. A system according to claim 10, wherein any one of the utilities that optimise the placement of the plurality of containers within the facility, further comprises updating means for updating stock levels of the facility based on the depletion of one or more of the plurality of objects within the facility.

15. A system according to any preceding claim comprising one or more further utilities that control movement or operations on one or more of the containers conducted within one or more workstations.

16. A system according to claim 10 wherein any one of the utilities further comprises control means that controls the movement of the one or more of transporting devices based at least on throughput of the one or more workstations.

17. A system according to any preceding claim wherein any one of the utilities provides a clearance system, said system comprising configuring means arranged to enable the system to be tolerant of missed communications with at least one of the one or more transporting devices.

18. A system according to any preceding claim wherein any one of the utilities comprises determining and reserving means arranged to determine and reserve routes, and instruct a plurality of transporting devices to cooperate in transporting one or more of the plurality of containers.

19. A system according to any preceding claim wherein any one of the utilities further comprises determining means arranged to determine and reserve routes to move idle transporting devices from otherwise optimal routes for other transporting devices.

20. A system according to any preceding claim, wherein the facility is divided into a plurality of sub-grids.

21. A system according to any preceding claim, wherein one or more control commands to control the movement of the plurality of transporting devices is provided to the plurality of transporting devices in advance of the movement of the plurality of transporting devices.

22. A system according to any preceding claim wherein any one of the utilities comprises optimising means arranged to optimise the return of the or each container into the most optimal of the vacant positions in the stacks within the facility.

23. A system according to any preceding claim wherein any one of the utilities comprises operating means arranged to dynamically substitute damaged or missing objects from alternative containers within the stack.

24. A system according to any preceding claim wherein any one of the utilities comprises further optimizing means for the remainder of the stack on a cost function analysis.

25. A storage system comprising:

a first set of parallel rails or tracks extending in the X-direction, and a second set of parallel rails or tracks extending in a Y-direction transverse to the first set in a substantially horizontal plane to form a grid pattern comprising a plurality of grid spaces;

a plurality of stacks of containers located beneath the rails, and arranged such that each stack is located within a footprint of a single grid space;

a multiplicity of load handling devices, each load handling device being arranged to selectively move laterally in the X and Y directions, above the stacks on the rails; and

a system according to any preceding claim.

26. The storage system according to Claim 23, wherein each load handling device has a footprint that occupies only a single grid space in the storage system, such that a load handling device occupying one grid space does not obstruct a load handling device occupying or traversing the adjacent grid spaces in the X and Y directions.

27. A method arranged to control the movement of one or more transporting devices arranged to transport a plurality of containers, said devices arranged to

operate in a facility, the facility comprising the plurality of containers arranged in a plurality of stacks, the facility further having a plurality of pathways arranged in a grid-like structure above the stacks, the one or more transporting devices arranged to operate on the grid-like structure, the method comprising:

determining and reserving routes for moving the one or more transporting devices through the plurality of pathways;

determining and reserving routes for moving the one or more transporting devices when transporting one or more of the plurality of containers;

determining and controlling retrieval of one or more of the plurality of containers by the one or more transporting devices from within one or more of the plurality of stacks, wherein retrieval of the one or more containers from within the one or more stacks further requires moving one or more other containers in the stack prior to accessing the one or more containers for retrieval; and

moving the one or more other containers from within one or more to an alternative position within the facility,

wherein the alternative position is determined from an available pool of empty locations within any one of the stacks other than the stack from which the or each container was removed.

28. A method according to claim 27, wherein the alternative position is determined by scoring, with a configurable, weighted cost function, each stack location based on the average distance from all workstations, distance from a closest workstation and an approximate dig cost.

29. A method according to claim 28, wherein the alternative position is determined based on a difference between the scoring of the configurable, weighted cost function and a length of the path from a source to the stack location and for how long the stack is reserved.

30. A method according to claim 28 or claim 29, wherein the alternative position is determined based on at least one of: the total weight of the stack, and controlling the position of hazardous or special substances.

31. A method according to any of claims 27 to 30, wherein the alternative position is determined based on at least one of: the layout of the grid-like structure, the frequency at which a particular item is requested, future ordering, predicted future ordering, the location of workstations, the location of charging stations, and the congestion level of particular areas and branches of the pathway.

32. A method according to any of claims 27 to 31 in which the containers contain objects for storage and retrieval from within the facility.

33. A method according to any of claims 27 to 32 further comprising the step of providing a clearance system for permitting or stopping movement of the one or more transporting devices to avoid collisions.

34. A method according to any one of claims 27 to 33 further comprising the step of optimising the movement and actions of the one or more transporting devices through the plurality of pathways.

35. A method according to claim 34 further comprising the step of optimising the placement of the plurality of containers by the one or more transporting devices in the facility.

36. A method according to claim 34 or claim 35 wherein optimising the movement and actions of the or each transporting device comprises using one or more path finding algorithms.

37. A method according to claim 34 or claim 35 wherein optimising the movement and actions of the or each transporting device comprises using one or more congestion mitigation techniques.

38. A method according to claim 34 or claim 35 wherein optimising the movement and actions of the or each transporting device comprises using one or more machine learning techniques.

39. A method according to claim 35 wherein optimising the placement of the plurality of containers within the facility, and updating stock levels of the facility is based on the depletion of one or more of the plurality of objects within the facility.

40. A method according to any of claims 27 to 39 further comprising the step of controlling movement of or operations on the or each of the containers conducted within one or more workstations.

41. A method according to claim 34 wherein controlling the movement of the one or more of transporting devices is based at least on throughput of the one or more workstations.

42. A method according to any one of claims 27 to 41 comprising the further step of providing clearances tolerant to missed communications with at least one of the one or more transporting devices.

43. A method according to any one of claims 27 to 42 comprising the further step of instructing a plurality of transporting devices to cooperate in transporting one or more of the plurality of containers.

44. A method according to any one of claims 27 to 43 further comprising the step of determining and reserving routes to move idle transporting devices from otherwise optimal routes for other transporting devices.

45. A method according to any one of claims 27 to 44 wherein the facility is divided into a plurality of sub-grids.

46. A method according to any one of claims 27 to 45, wherein one or more control commands for controlling the movement of the plurality of transporting devices is provided to the plurality of transporting devices in advance of the movement of the plurality of transporting devices.

47. A system method according to any one of claims 27 to 46 wherein one or more utilities is provided to determine a further optimization of the remainder of the stack on a cost function analysis.

48. A system arranged to control movement of a plurality of transporting devices, the plurality of transporting devices arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility comprising a plurality of pathways arranged in a grid-like structure above the stacks, the plurality of transporting devices arranged to operate on the grid-like structure, the system comprising:

a movement optimisation means (304) arranged to determine a route from one location on the grid-like structure to another location on the grid-like structure for each transporting device;

a reservation means (314) arranged to reserve a path on the grid-like structure for each of the plurality of transporting devices based on the determined route, wherein the path reserved for each transporting device is provided such that no two transporting devices have locations on the grid-like structure which would cause transporting devices to overlap at the same time; and

a clearance means (312) arranged to provide clearance for each transporting device to traverse a portion of the reserved path.

49. The system according to Claim 48, wherein the clearance means (312) is arranged to grant or withhold providing clearance for a transporting device to traverse a portion of the reserved path in response to a status report received from each transporting device.

50. The system according to Claim 48 or Claim 49, wherein the clearance module (312) is implemented as a passive collision avoidance system, wherein transporting devices are only given the smallest amount of work possible without impacting performance.

51. The system according to any of Claims 48 to 50, wherein the clearance means (312) is arranged to grant or withhold providing clearance for a transporting device to traverse a portion of the reserved path based on at least one of: dimensions of the grid-like structure, positions on the grid-like structure, commands to move the transporting device, cancellation of commands to move the transporting device, the current positions and speeds of the plurality of transporting devices, a braking ability of the plurality of transporting devices and clearances provided to the plurality of transporting devices.

52. The system according to any of Claims 48 to 51, wherein the clearance means (312) and/or the movement optimisation means (304) is further arranged to dynamically re-plan a route of at least one transporting device.

53. The system according to any of Claims 48 to 52, when at least one message is not received by the system from the transporting device, the movement optimisation means (304) is arranged to recalculate the route for a transporting device when a transporting device traverses the portion of the reserved path so as to resolve or avoid conflicts.

54. The system according to any of Claims 48 to 53, wherein the clearance means (312) is arranged to provide clearance based upon a set of tolerances, including at least one of: missed messages, processing time, clock sync and transporting device discrepancies with a physics model.

55. The system according to any of Claims 48 to 54, wherein the clearance means (312) is arranged to calculate a set of safe entry times for at least one position on the grid-like structure based upon transporting device position and speed updates, and clearances given and withheld.

56. The system according to any of Claims 48 to 55, wherein the clearance means (312) is arranged to provide clearances for a predetermined period of time.

57. The system according to any of Claims 48 to 56, the system further comprising a control means (202, 302) arranged to control movement of the plurality of transporting devices.

58. The system according to Claim 57, wherein the clearance means (312) is arranged to provide to the control means (202, 302) at least one of: the clearances required to traverse a reserved path, notification of when a clearance is issued, notification of when a clearance is withheld and problems with a transporting device,

wherein the control means (202, 302) is arranged to control movements of the plurality of transporting devices based on the information received from the clearance means (312).

59. A storage system comprising:

a first set of parallel rails or tracks extending in the X-direction, and a second set of parallel rails or tracks extending in a Y-direction transverse to the first set in a substantially horizontal plane to form a grid pattern comprising a plurality of grid spaces;

a plurality of stacks of containers located beneath the rails, and arranged such that each stack is located within a footprint of a single grid space;

a multiplicity of load handling devices, each load handling device being arranged to selectively move laterally in the X and Y directions, above the stacks on the rails; and

a system according to any of Claims 48 to 58.

60. The storage system according to Claim 59, wherein each load handling device has a footprint that occupies only a single grid space in the storage system, such that a load handling device occupying one grid space does not obstruct a load handling device occupying or traversing the adjacent grid spaces in the X and Y directions.

61. A method arranged to control movement of a plurality of transporting devices, the plurality of transporting devices arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility comprising a plurality of pathways arranged in a grid-like structure above the stacks, the plurality of transporting devices arranged to operate on the grid-like structure, the method comprising the steps of:

determining a route from one location on the grid-like structure to another location on the grid-like structure for each transporting device;

reserving a path on the grid-like structure for each of the plurality of transporting devices based on the determined route, wherein the path reserved for each transporting device is provided such that no two transporting devices have locations on the grid-like structure which would cause transporting devices to overlap at the same time; and

providing clearance for each transporting device to traverse a portion of the reserved path.

62. The method according to Claim 61, wherein the step of providing clearance comprises granting or withholding clearance for a transporting device to traverse a portion of the reserved path in response to a status report received from each transporting device.

63. A system arranged to control movement of a plurality of transporting devices, the plurality of transporting devices arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility comprising a plurality of pathways arranged in a grid-like structure above the stacks, the plurality of transporting devices arranged to operate on the grid-like structure, the system comprising:

a control means (202) arranged to determine at least one task to be performed by at least one of the plurality of transporting devices,

wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on at least one of: transporting

device battery condition, transporting device damage, transporting device maintenance issues, and transporting device service issues.

64. The system according to Claim 63, wherein the at least one task comprises one of: moving from a first location on the grid-like structure to a second location on the grid-like structure, communicating with the control means (202), communicating with another transporting device, coordinating movement with another transporting device, transporting containers each of which may contain one of more items, lifting containers from the stacks, lowering containers into the stacks, delivering empty containers to inbound stations, placing containers loaded with goods around the facility, bringing containers to pick stations or other areas, and moving containers from one location in the facility to another.

65. The system according to Claim 63 or Claim 64, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device is malfunctioning.

66. The system according to any of claims 63 to 65, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device requires charging.

67. The system according to any of claims 63 to 66, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device can perform the task given a set amount of battery life.

68. The system according to any of claims 63 to 67, wherein the control means (202) is arranged to receive a status report from each of the plurality of transporting devices.

69. The system according to any of claims 63 to 68, the control means (202) comprising a movement control means (302) arranged to control movement of the plurality of transporting devices.

70. A storage system comprising:

a first set of parallel rails or tracks extending in the X-direction, and a second set of parallel rails or tracks extending in a Y-direction transverse to the first set in a

substantially horizontal plane to form a grid pattern comprising a plurality of grid spaces;

a plurality of stacks of containers located beneath the rails, and arranged such that each stack is located within a footprint of a single grid space;

a multiplicity of load handling devices, each load handling device being arranged to selectively move laterally in the X and Y directions, above the stacks on the rails; and

a system according to any of claims 63 to 69.

71. The storage system according to Claim 70, wherein each load handling device has a footprint that occupies only a single grid space in the storage system, such that a load handling device occupying one grid space does not obstruct a load handling device occupying or traversing the adjacent grid spaces in the X and Y directions.

72. A method for controlling movement of a plurality of transporting devices, the plurality of transporting devices arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility comprising a plurality of pathways arranged in a grid-like structure above the stacks, the plurality of transporting devices arranged to operate on the grid-like structure, the method comprising the step of:

determining at least one task to be performed by at least one of the plurality of transporting devices,

wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on at least one of: transporting device battery condition, transporting device damage, transporting device maintenance issues, and transporting device service issues.

73. The method according to Claim 72, wherein the at least one task comprises one of: moving from a first location on the grid-like structure to a second location on the grid-like structure, communicating with a control means, communicating with another transporting device, coordinating movement with another transporting device, transporting containers each of which may contain one of more items, lifting containers from the stacks, lowering containers into the stacks, delivering empty containers to inbound stations, placing containers loaded with goods around the facility, bringing containers to pick stations or other areas, and moving containers from one location in the facility to another.

74. The method according to Claim 72 or Claim 73, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device is malfunctioning.

75. The method according to any of claims 72 to 74, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device requires charging.

76. The method according to any of claims 72 to 75, wherein the at least one task to be performed by the at least one of the plurality of transporting devices is determined based on whether the transporting device can perform the task given a set amount of battery life.

77. The method according to any of claims 72 to 76, the method further comprising the step of receiving a status report from each of the plurality of transporting devices.

78. A system arranged to control movement of at least one transporting device, the at least one transporting device arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility further comprising a plurality of pathways arranged in a grid-like structure above the plurality of stacks, the at least one transporting device being arranged to operate on the grid-like structure, the system comprising:

a receiving unit arranged to receive information about a product to be returned to a container in the plurality of stacks, wherein the product is located at a workstation; and

a control unit arranged to, based on the information about the product, select a container in the plurality of stacks into which the product is to be placed and instruct a transporting device to move the selected container to a location of the workstation.

79. The system according to Claim 78, wherein the received information comprises a product identifier and/or an expiry date of the product.

80. The system according to Claim 78 or Claim 79, wherein the product was previously picked from a container in the plurality of stacks.

81. The system according to any of Claims 78 to 80, wherein the product is to be returned to the plurality of stacks because an order for the product was cancelled, a delivery of the product to a customer has failed and/or the product was returned by the customer.

82. The system according to any of Claims 78 to 81, further comprising a placing unit arranged to place, when the selected container arrives at the workstation, the product in the selected container.

83. The system according to any of Claims 78 to 82, further comprising an instructing unit arranged to instruct a worker, when the selected container arrives at the workstation, to place the product in the selected container.

84. The system according to any of Claims 78 to 83, wherein the control unit is arranged, when the product has been placed in the selected container, to move the selected container to a location within the plurality of stacks.

85. The system according to any of Claims 78 to 84, further comprising a workstation control unit arranged to control movement and/or operations conducted within at least one workstation.

86. The system according to Claim 85, wherein the workstation control unit is further arranged to control at least one workstation to reject, repackage or rework the product to be returned.

87. The system according to any of Claims 78 to 86,

wherein the receiving unit is arranged to receive information about a returned container,

the information comprises an identity of the returned container,

the returned container is arranged to contain the product to be returned, and

the returned container is located at the workstation.

88. The system according to Claim 87, wherein the control unit is arranged to, based on the information about the returned container, select at least one container in the plurality of stacks into which at least one product contained in the returned container is to be placed and instruct at least one transporting device to move the at least one selected container to the location of the workstation.

89. The system according to Claim 88, further comprising a confirming unit arranged to ask a worker, after placing the product in the selected at least one container, to confirm that there are no further products of the same product identifier in the returned container.

90. A storage system comprising:

a first set of parallel rails or tracks extending in the X-direction, and a second set of parallel rails or tracks extending in a Y-direction transverse to the first set in a substantially horizontal plane to form a grid pattern comprising a plurality of grid spaces;

a plurality of stacks of containers located beneath the rails, and arranged such that each stack is located within a footprint of a single grid space;

a multiplicity of load handling devices, each load handling device being arranged to selectively move laterally in the X and Y directions, above the stacks on the rails; and

a system according to any of Claims 78 to 89.

91. The storage system according to Claim 90, wherein each load handling device has a footprint that occupies only a single grid space in the storage system, such that a load handling device occupying one grid space does not obstruct a load handling device occupying or traversing the adjacent grid spaces in the X and Y directions.

92. A method for controlling movement of at least one transporting device, the at least one transporting device arranged to transport containers, the containers being stored in a facility, the facility arranged to store the containers in a plurality of stacks, the facility further comprising a plurality of pathways arranged in a grid-like structure above the plurality of stacks, the at least one transporting device being arranged to operate on the grid-like structure, the method comprising the steps of:

receiving information about a product to be returned to a container in the plurality of stacks, wherein the product is located at a workstation;

selecting, based on the information about the product, a container in the plurality of stacks into which the product is to be placed; and

instructing a transporting device to move the selected container to a location of the workstation.