CLAIMS

What is claimed is:

1. A multi-zone automated storage and retrieval system (ASRS), said automated storage and retrieval system comprising:

a plurality of storage locations configured to accommodate placement and storage of storage units therein;

a plurality of environmentally controlled temperature zones, said environmentally controlled storage zones including:

a first storage zone comprising a first group of the storage locations, said first storage zone being an ambient storage zone;

a second storage zone comprising a second group of the storage locations, the second storage zone isolated from the first storage zone by at least one barrier; and

a third storage zone, the third storage zone isolated from the first storage zone and the second storage zone by at least one additional barrier, and wherein the second storage zone and the third zone are cooled storage zones having a lower environmental operating temperature than the first storage zone;

at least one portal opening through the at least one barrier between the first storage zone and the second storage zone;

at least one track layout comprising a first track area occupying the first storage zone, a second track area occupying the second storage zone, and at least one connective track segment interconnecting the first track area and the second track area through the at least one portal configured in the at least one barrier;

a plurality of robotic storage/retrieval vehicles (RSRVs) configured to deposit and retrieve the storage units to and from the storage locations, wherein the RSRVs are further configured to travel on the at least one track layout on both the first track area and the second track area to respectively access the first group of the storage locations and the second group of the storage locations therefrom, and wherein the RSRVs are further configured to travel between the

first track area and the second track area via the at least one connective track segment interconnecting the first track area and the second track area;

a computerized control system (CCS) in operable communication with the RSRVs, the computerized control system comprising at least one processor, the computerized control system configured to:

during selection of an RSRV for a storage unit retrieval task associated with the second storage zone, prioritize the RSRVs of a longer absence from the second storage zone over the RSRVs of a more recent presence in the second storage zone;

assign a temperature weight to each of the RSRVs, based on a duration since each of the RSRVs was last exposed to an environmentally controlled temperature zone;

normalize the temperature weight assigned to each of the RSRVs based on a duration of last exposure of each of the RSRVs to the environmentally controlled temperature zone and environmental characteristics of the environmentally controlled temperature zone to which each of the RSRVs was last exposed;

select an RSRV with a highest temperature weighting to perform the storage unit retrieval task associated with the second storage zone; and

select an RSRV with a low temperature weighting to perform the storage unit retrieval task associated with the first storage zone.

2. The multi-zone automated storage and retrieval system of claim 1, wherein the first storage zone, the second storage zone, and the third storage zone differ from one another in one of environmental control equipment installed therein and operating characteristics of the environmental control equipment, and wherein the first storage zone, the second storage zone, and the third storage zone are accessible by the RSRVs.

3. The multi-zone automated storage and retrieval system of claim 1, wherein:

the at least one track layout comprises an upper track layout positioned above the storage locations;

the at least one barrier comprises an upper portion standing upright from the

upper track layout;

the at least one portal is configured to open through the at least one barrier at the upper portion thereof to accommodate a connective track segment of the upper track layout that interconnects the first track area and the second track area of the upper track layout; and

the at least one additional barrier comprises an upper portion standing upright from the upper track layout.

4. The multi-zone automated storage and retrieval system of claim 1, wherein the at least one track layout further comprises a lower track layout positioned below the storage locations, and wherein the at least one barrier comprises a lower portion standing upright from the lower track layout, and wherein the at least one portal is configured to open through the at least one barrier at the lower portion thereof to accommodate a connective track segment of the lower track layout that interconnects the first track area and the second track area of the lower track layout.

5. The multi-zone automated storage and retrieval system of claim 4, wherein the storage units stored in the first group of the storage locations and the second group of the storage locations are accessible by one of a plurality of workstations attached to the lower track layout that extends continuous to the first storage zone and the second storage zone.

6. The multi-zone automated storage and retrieval system of claim 1, wherein:

the third storage zone comprises a third group of the storage locations; and

at least one additional portal opening through the at least one additional barrier between the third storage zone and at least one of the first storage zone and the second storage zone, wherein the at least one additional portal is configured to accommodate travel of the RSRVs therethrough.

7. The multi-zone automated storage and retrieval system of claim 6, wherein the at least one additional barrier comprises a plurality of additional portals opening to both the first storage zone and the second storage zone.

8. The multi-zone automated storage and retrieval system of claim 6, wherein the at least one additional portal comprises at least one upper portal opening through the at least one additional barrier at the upper portion thereof.

9. The multi-zone automated storage and retrieval system of claim 1, wherein:

the multi-zone automated storage and retrieval system further comprises a plurality of buffer spots, wherein each of the buffer spots is positioned at a location on the at least one track layout and accessible by the RSRVs from the at least one track layout, and wherein each of the buffer spots is configured to temporarily hold one of the storage units thereon, and wherein at least one of the buffer spots is positioned proximal to the at least one portal, and wherein at least one of remaining buffer spots is positioned in each of the first storage zone and the second storage zone; and

the processor is configured to:

as a part of the retrieval task associated with the second storage zone requiring retrieval of a targeted storage unit stored in the second storage zone, assign the retrieval task to a first RSRV selected from among the RSRVs located in the first storage zone; and

issue commands to the first RSRV to:

travel into the second storage zone via the at least one portal opening thereinto from the first storage zone; and

during the travel, prior to entering the second storage zone through the at least one portal, drop off a storage unit currently carried on the first RSRV at the at least one buffer spot located in the first storage zone.

10. The multi-zone automated storage and retrieval system of claim 9, wherein the processor is further configured to:

in additional steps of the retrieval task associated with the second storage zone, further issue commands to the first RSRV to:

upon entry into the second storage zone, pick up a buffered storage unit from the at least one buffer spot in the second storage zone;

travel from the at least one buffer spot in the second storage zone towards an access location in the second storage zone from which the targeted storage unit stored in the second storage zone is retrievable; and

prior to retrieving the targeted storage unit at the access location, deposit

the buffered storage unit picked up from the second storage zone into an available storage location in the second storage zone.

11. The multi-zone automated storage and retrieval system of claim 10, wherein the processor is further configured to select the available storage location in the second storage zone from among storage locations available upstream and positioned en route from the at least one buffer spot in the second storage zone to the access location, and among storage locations available downstream and positioned en route from the access location to an exit portal of the second storage zone.

12. The multi-zone automated storage and retrieval system of claim 10, wherein the processor is further configured to:

complete the retrieval task associated with the second storage zone by issuing commands to the first RSRV to retrieve the targeted storage unit stored in the second storage zone and deliver the targeted storage unit to a workstation to facilitate picking of products from the targeted storage unit at the workstation;

subsequent to completion of the retrieval task associated with the second storage zone and picking of the products from the targeted storage unit carried by the first RSRV, issue commands to one of:

the first RSRV and a different RSRV to deposit the targeted storage unit onto the at least one buffer spot in the second storage zone and exit the second storage zone; and

as part of a subsequent retrieval task associated with the second storage zone and assigned to a second RSRV selected from amongst the first RSRV and the different RSRV, to retrieve another targeted storage unit stored in the second storage zone, issue commands to the second RSRV to:

enter the second storage zone;

pick up the targeted storage unit deposited by one of the first RSRV and the different RSRV from the at least one buffer spot in the second storage zone;

travel from the at least one buffer spot in the second storage zone

towards an access location in the second storage zone from which the another targeted storage unit is retrievable; and

prior to retrieving the another targeted storage unit at the access location, deposit the targeted storage unit picked up from the at least one buffer spot in the second storage zone into an available storage location in the second storage zone.

13. The multi-zone automated storage and retrieval system of claim 1, wherein the processor is further configured to assign a task of depositing an unneeded storage unit stored in the second storage zone into one of the storage locations in the second group, to one of the RSRVs that is assigned to retrieve a needed storage unit stored in the second storage zone comprising the second group of the storage locations.

14. The multi-zone automated storage and retrieval system of claim 1, wherein the at least one barrier isolating the second storage zone from the first storage zone comprises an upright barrier wall separating the first storage zone and the second storage zone, and wherein the at least one connective track segment spans through the at least one portal from one side of the upright barrier wall to another side of the upright barrier wall.

15. The multi-zone automated storage and retrieval system of claim 1, wherein the second storage zone comprising the second group of the storage locations further includes an enclosed attic space positioned above the at least one track layout and isolated from the first storage zone, and wherein the first storage zone is free of the enclosed attic space and is open to a surrounding environment of a facility that accommodates the multi-zone automated storage and retrieval system.

16. The multi-zone automated storage and retrieval system of claim 15, wherein:

the enclosed attic space is delimited by boundary walls of the second storage zone;

at least one of the boundary walls is separate and discrete from building walls of the facility;

the enclosed attic space is isolated from the first storage zone and from a surrounding space of the facility;

the boundary walls of the enclosed attic space are separate and discrete from walls of the facility, and the boundary walls are mounted to frame members of a gridded storage structure of the multi-zone automated storage and retrieval system that delimits the second group of the storage locations.

17. The multi-zone automated storage and retrieval system of claim 1, wherein the storage locations are arranged in storage columns configured to receive the placement of the storage units therein, and wherein the RSRVs are configured to travel on the at least one track layout between access locations at which different storage columns are accessible by the RSRVs to deposit and retrieve the storage units into and from the storage columns.

18. The multi-zone automated storage and retrieval system of claim 17, wherein the access locations comprise unoccupied access shafts around which the storage columns are clustered and through which the RSRVs are configured to travel to access multiple levels of the storage columns, wherein each of the unoccupied access shafts is neighbored by at least one of the storage columns to and from which the storage units are placeable and retrievable by the RSRVs from within each of the unoccupied access shafts.

19. The multi-zone automated storage and retrieval system of claim 1, wherein the storage units containing product inventory are received at a receiving facility on a transport vehicle from a supply facility and automatically inducted into the multi-zone automated storage and retrieval system (ASRS) at the receiving facility, and wherein the multi-zone ASRS is of a type compatible with a predetermined type of the storage units, and wherein the storage units containing the product inventory are exchanged for outgoing storage units from the receiving facility, by loading the outgoing storage units onto the transport vehicle for transit from the receiving facility, and wherein the storage units containing the product inventory and the outgoing storage units are of the same predetermined type compatible with the multi-zone ASRS of the receiving facility.

20. A computer-implemented method executable in a multi-zone automated storage and retrieval system (ASRS), the multi-zone ASRS comprising:

a plurality of storage locations configured to accommodate placement and storage of storage units therein;

a plurality of environmentally controlled temperature zones, said environmentally controlled storage zones including:

a first storage zone comprising a first group of the storage locations, said first storage zone being an ambient storage zone;

a second storage zone comprising a second group of the storage locations, the second storage zone isolated from the first storage zone by at least one barrier;

a third storage zone, the third storage zone isolated from the first storage zone and the second storage zone by at least one additional barrier, and wherein the second storage zone and the third zone are cooled storage zones having a lower environmental operating temperature than the first storage zone; and

a plurality of robotic storage/retrieval vehicles (RSRVs) configured to deposit and retrieve the storage units to and from the storage locations;

the method comprising a step of employing a computerized control system (CCS) to:

during selection of an RSRV for a storage unit retrieval task associated with the second storage zone, prioritize the RSRVs of a longer absence from the second storage zone over the RSRVs of a more recent presence in the second storage zone;

assign a temperature weight to each of the RSRVs, based on a duration since each of the RSRVs was last exposed to an environmentally controlled temperature zone;

normalize the temperature weight assigned to each of the RSRVs based on a duration of last exposure of each of the RSRVs to the environmentally controlled temperature zone and environmental characteristics of the environmentally controlled temperature zone to which each of the RSRVs was last exposed;

select an RSRV with a highest temperature weighting to perform the storage unit retrieval task associated with the second storage zone; and

select an RSRV with a low temperature weighting to perform the storage

unit retrieval task associated with the first storage zone.

21. The computer-implemented method of claim 20, wherein the computerized control system includes a processor, the processor configured to:

for a deposit process in the second storage zone involving a deposit of a first storage unit to a first storage location in the second storage zone, divide the deposit process into a first entrance task of carrying the first storage unit into the second storage zone and a second placement task of placing the first storage unit into the first storage location;

assign the first entrance task and the second placement task to a first RSRV and a second RSRV respectively, the first RSRV and the second RSRV selected from among the RSRVs positioned outside the second storage zone; and

issue commands to the first RSRV and the second RSRV to execute the first entrance task and the second placement task, and wherein the first entrance task comprises a drop-off of the first storage unit in a buffer spot of the second storage zone by the first RSRV.

22. The computer-implemented method of claim 21, wherein the first entrance task comprises a prompt exit of the first RSRV from the second storage zone after the drop-off.

23. The computer-implemented method of claim 21, wherein the drop-off performed by the first RSRV in the first entrance task comprises placement of the first storage unit at the buffer spot in the second storage zone for later retrieval of the first storage unit from the buffer spot by the second RSRV.

24. The computer-implemented method of claim 21, wherein the processor is further configured to:

assign a retrieval task associated with the second storage zone to the second RSRV, wherein the retrieval task comprises retrieving a second storage unit from a second storage location in the second storage zone, and wherein the second storage location from which to retrieve the second storage unit is selected from among storage locations available upstream and positioned en route from the buffer spot in the second storage zone to the second storage

location in the second storage zone, and storage locations available downstream and positioned en route from the second storage location in the second storage zone to an exit portal of the second storage zone.

25. The computer-implemented method as claimed in claim 21, wherein the processor is further configured to:

(a) assign a retrieval task associated with the second storage zone to the first RSRV selected from among the RSRVs positioned outside the second storage zone;

(b) issue commands to the first RSRV to:

travel into the second storage zone;

retrieve the first storage unit from the first storage location in the second storage zone; and

exit the second storage zone and carry the first storage unit to a workstation positioned outside the second storage zone; and

(c) after performance of one of product placement to and product extraction from the first storage unit at the workstation, command one of the first RSRV and a different RSRV to transport the first storage unit from the workstation back into the second storage zone, and to drop-off the first storage unit at the buffer spot in the second storage zone that is distinct from storage locations of the second storage zone.

26. The computer-implemented method of claim 25, wherein the processor is further configured to issue commands to one of the first RSRV and the different RSRV to promptly exit the second storage zone after dropping off the first storage unit at the buffer spot in the second storage zone.

27. The computer-implemented method of claim 25, wherein the processor is further configured to issue commands to another RSRV to enter the second storage zone from the first storage zone, pick up the first storage unit from the buffer spot in the second storage zone, and deposit the first storage unit into one of the storage locations in the second storage zone.

28. The computer-implemented method of claim 27, wherein the processor is further configured to issue commands to the another RSRV to, after depositing the first

storage unit into one of the storage locations in the second storage zone, retrieve a second storage unit from a second storage location in the second storage zone.

29. The computer-implemented method of claim 27, wherein the processor is further configured to select the second storage location from among the storage locations in the second storage zone available upstream and positioned en route from the buffer spot to the second storage location, and the storage locations available downstream and positioned en route to an exit portal of the second storage zone from the second storage location.