Dragon Duds Warehouse Design[1]
SysML and RFLP

System Requirements

Dragon Duds receives garments from manufacturers in Asia, in cartons floor stacked in containers and ships push and pull orders to company stores. The context for Dragon Duds is shown below.

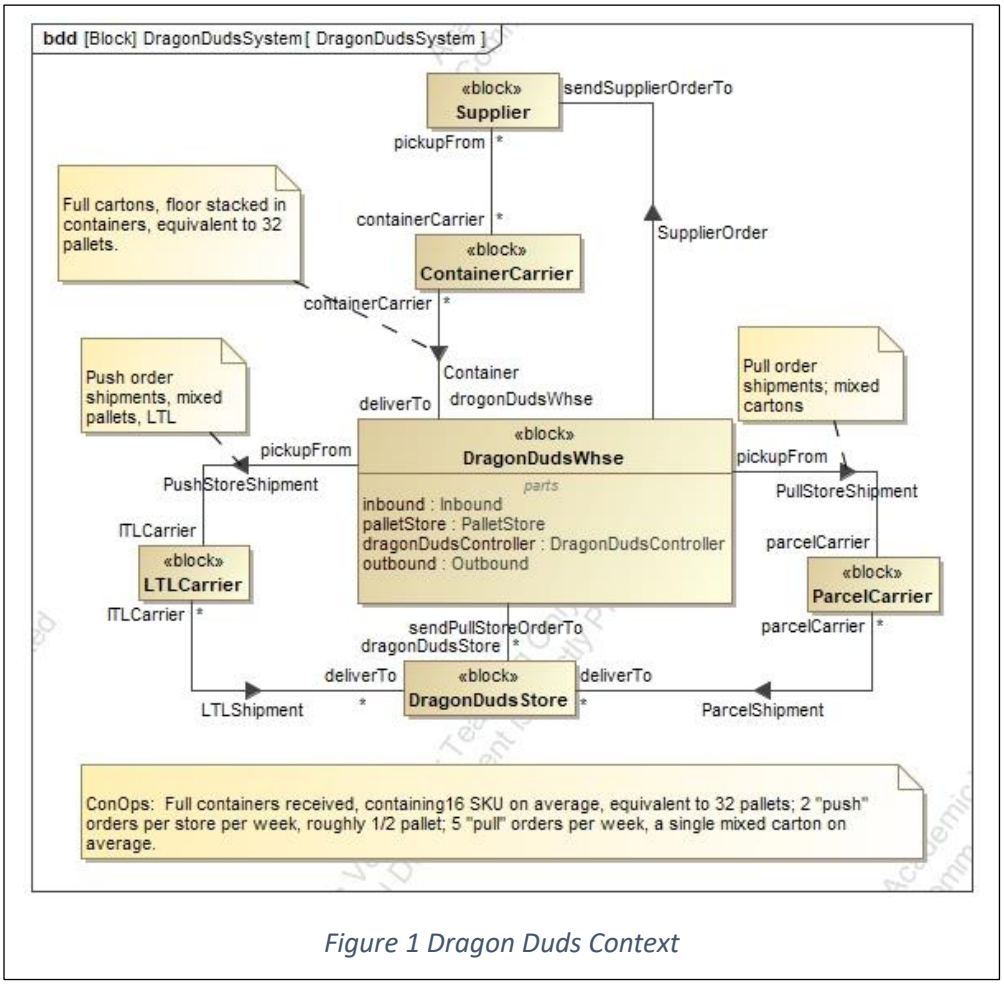

Figure 1 Dragon Duds Context

Based on the case data, the Dragon Duds warehouse (DDW) receives a single kind of product input (cartons in containers) and produces two kinds of shipped orders (mixed pallet push orders and mixed carton pull orders. This is shown in Figure 2.

The "design to" required rates for shipping and receiving are based on the following assumptions:

- Sales grow rate of 5% per year is applied to all stores, including the 50 added each year. The result is that in year 5 sales will be double those in the baseline year, and this applies equally to push and pull orders. Push orders go from 1000 per week to 2000 per week and pull orders go from 2500 per week to 5000 per week.

[1] Using *DragonDudsReqts.rev3.mdzip*

- Receiving of containers also will increase at the same rate, i.e., from 7 per day to 14 per day (11 max to 22 max).

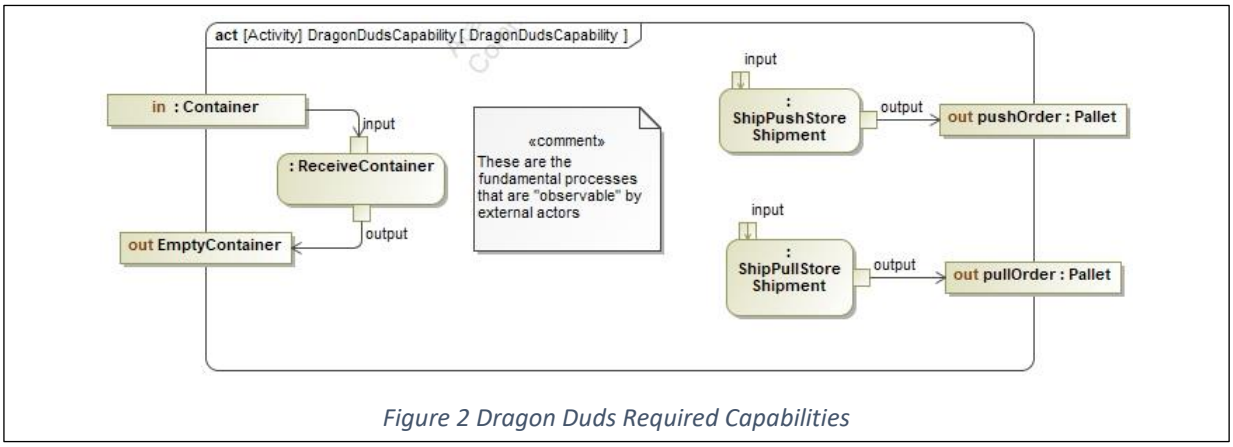

Figure 2 Dragon Duds Required Capabilities

Additional system requirements:

- Number of SKUs remains about the same
- Packaging does not change
- Sales pareto does not change

Functional Requirements

For DragonDuds Warehouse (DDW) the basic functions can be grouped into inbound, storage and outbound as show in Figure 3. Storage is required because of the differences in item arrival and departure rates.

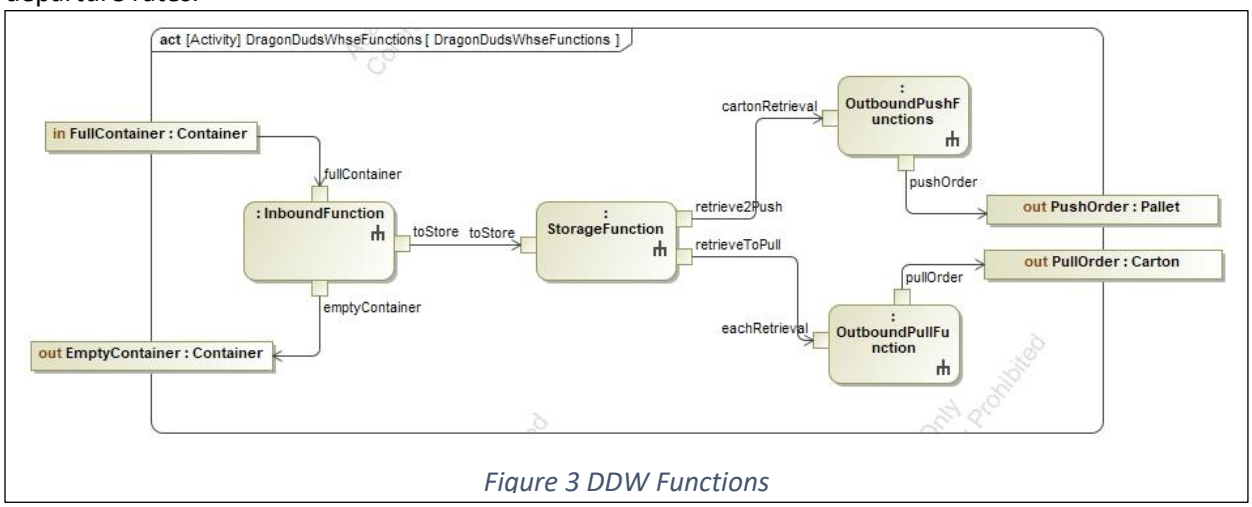

Figure 3 DDW Functions

The Inbound functions are described in more detail in Figure 4. Cartons first must be removed from the container in some manner. In the as-is system they are stacked on a pallet, but other methods could be considered. The removed cartons must be sorted to full pallets for putaway to storage. Once these pallets are completed (i.e., the container is completely unloaded, then they should be moved to storage. (Note: if the next container to be unloaded has some of the same SKUs, then perhaps the corresponding pallet should be kept in staging to accept additional cartons.)

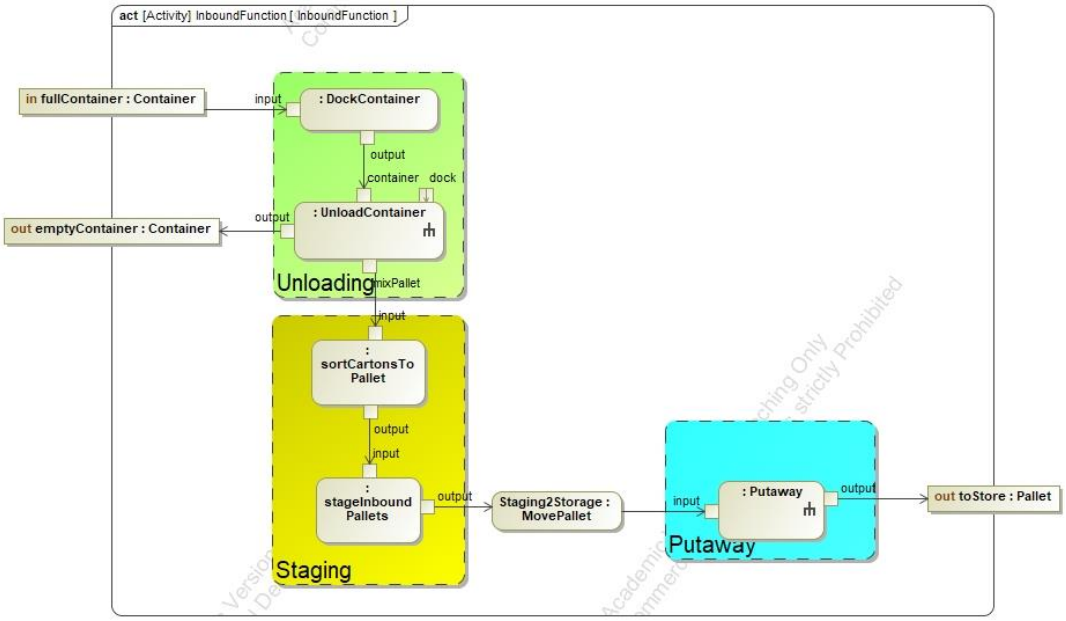

Figure 4 DDW Inbound Functions

Figure 5 shows the storage function in the as-is system, where received product is stored on pallets. While the as-is system uses pallet rack and block stacking, other approaches could be considered in the to-be system.

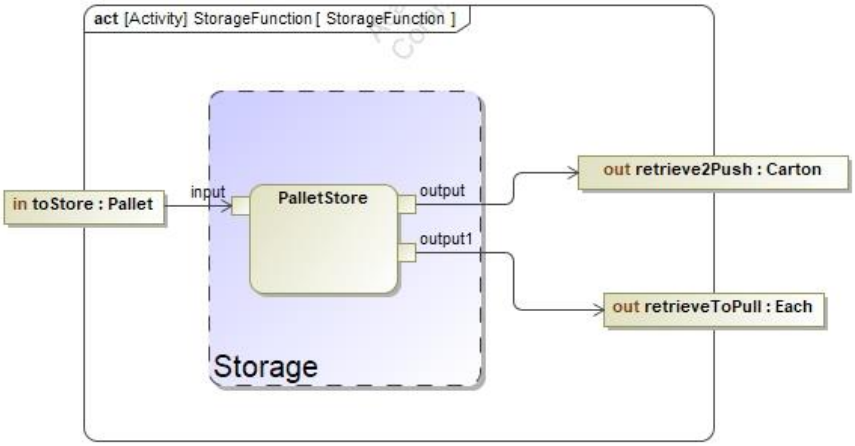

Figure 5 DDW Storage Function

Outbound functions can be divided into those associated with push and pull orders. The push order functions are shown in , and pull order functions in Figure 7.

The functional requirements identified so far only describe what DDW must be able to do. In designing *how* these functions will be implemented, they may be elaborated into sub-functions in order to achieve design goals for efficiency in resources, time or cost.

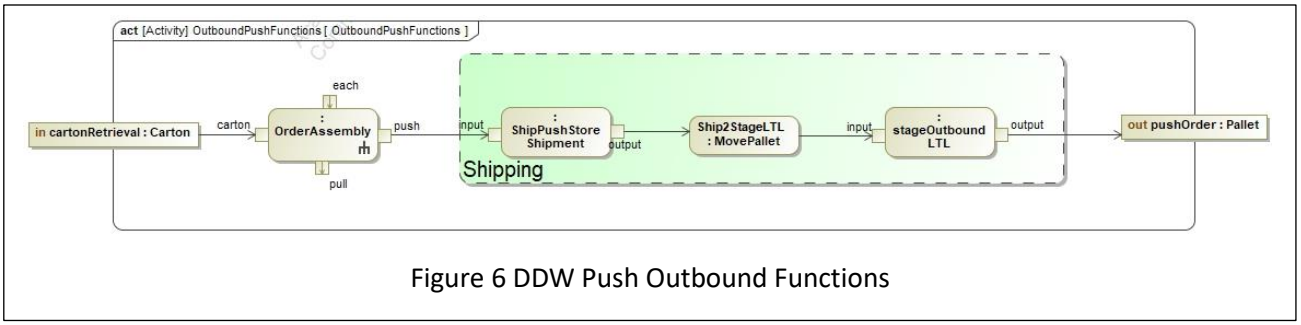

Figure 6 DDW Push Outbound Functions

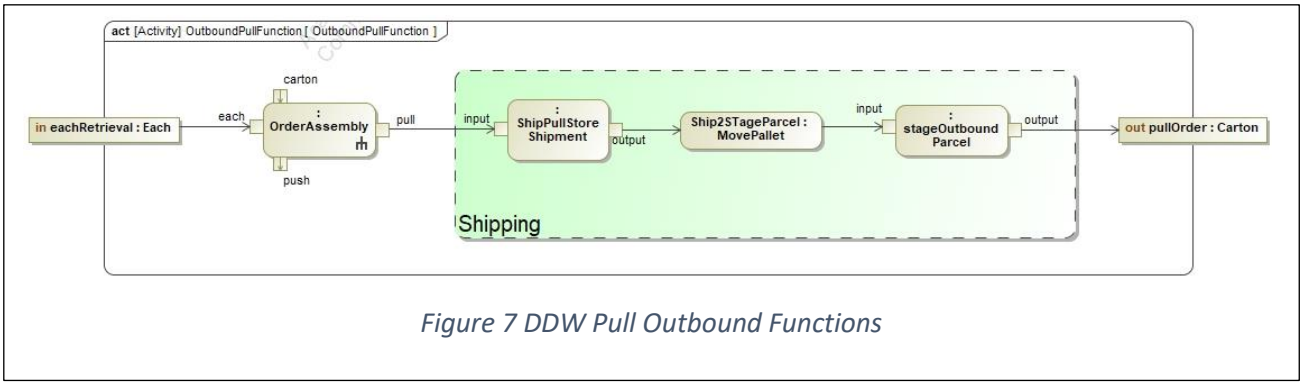

Figure 7 DDW Pull Outbound Functions

Logical Architecture

Dragon Duds products differ dramatically over time in terms of sales and inventory. For example, in the peak shipping month, about 13% of the SKUs had zero sales while 3% of SKUs represented 48.3% of volume shipped, or over 2000 pallets/month (an average of almost 40 pallets per month for each product in this group). What this indicates is that the products are highly seasonal—during some part of the year a given product may have zero sales while in another part of the year it may represent a large fraction of total sales.

Two different logical architectures are proposed below. It should be clear that these are not the only two possibilities. For example, LA2 has a forward pick area with pallet gravity flow rack (for extremely fast-moving products) and carton shelving. A third option might be to augment LA2 with some carton flow rack for items that are "in between" the volume supported by gravity flow rack and the volume supported by carton shelving.

Logical Architecture 1 (LA1): In Figure 8, there are only two storage functions, pallet rack and floor storage, and a given SKU is assigned to one or the other and never changes (although it may have no assigned storage function when its inventory is zero). Both storage functions will allow either carton or each How the elaborated storage function fits into the functional requirements of Figure 3 is shown in Figure 9

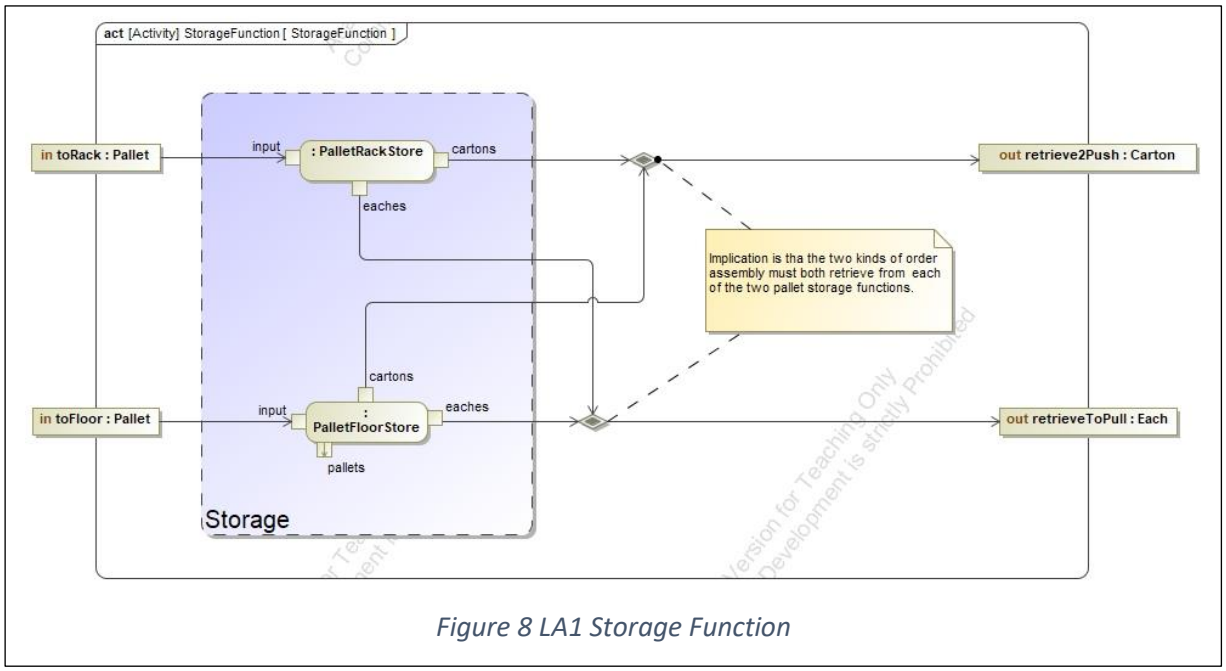

Figure 8 LA1 Storage Function

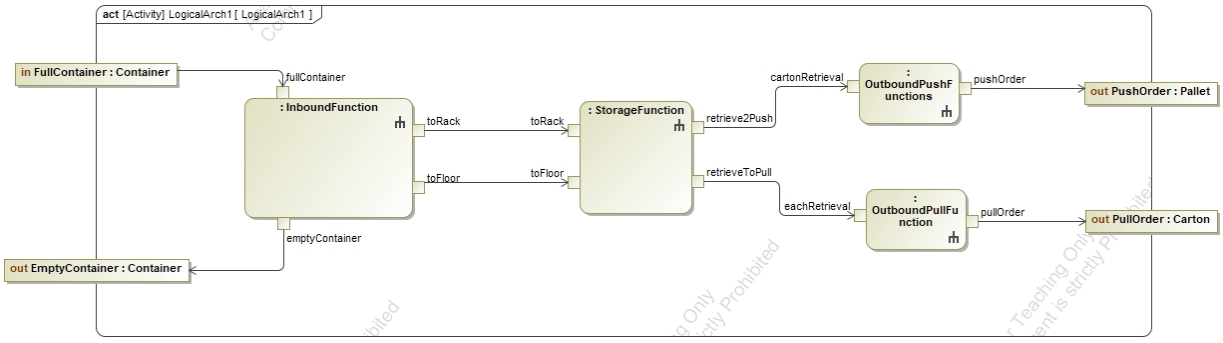

Figure 9 Logical Architecture 1

Logical Architecture 2 (LA2): For LA2, distinct forward picking zones are defined for fast moving cartons and eaches. The resulting storage function is shown in Figure 10. Note that the inputs and outputs for the storage functions are the same in both Figure 8 and Figure 10.

The overall organization for LA2 will be exactly the same as shown in Figure 9, but the details of the storage function will be quite different.

Next Steps

For each logical architecture there will be a number of required design decisions before a final performance assessment can be conducted.

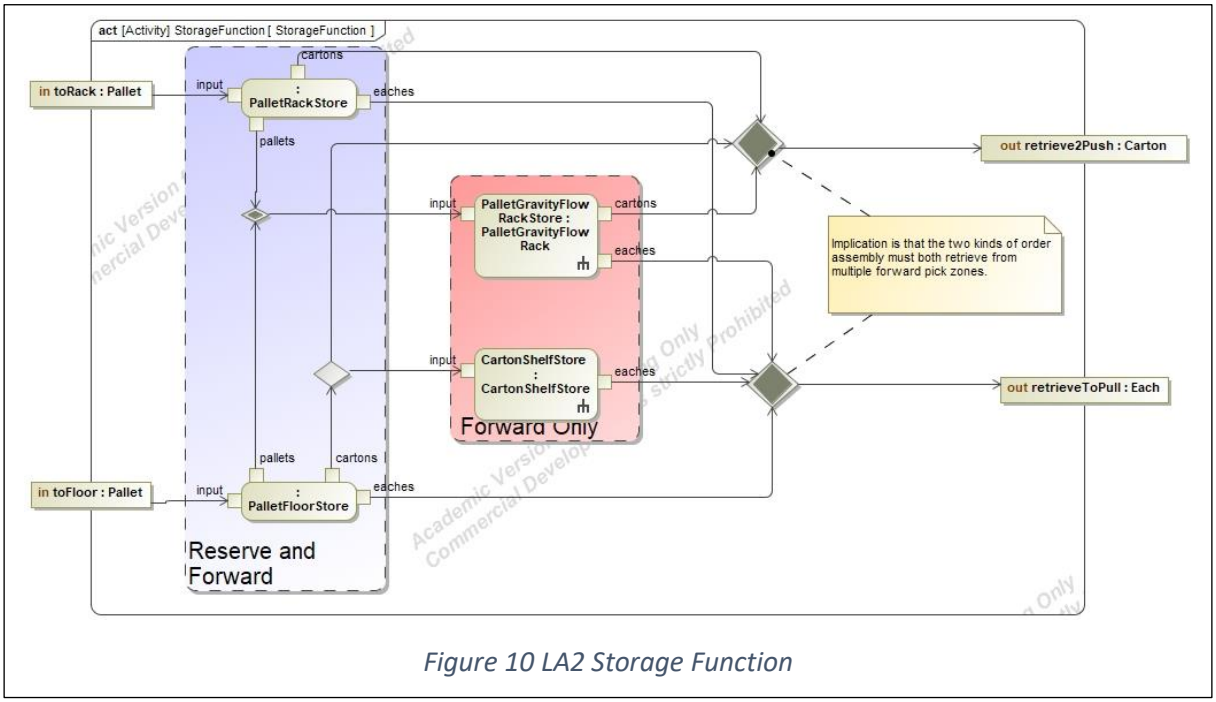

Figure 10 LA2 Storage Function

For LA1 there are four paths through the storage function, a push order may require cartons from both storage functions and a pull order also may require eaches from both storage functions. Thus the decision about assigning SKU to reserve storage zone, along with the order profile, will determine the rates of flow on these four paths. For both reserve storage options, the number of storage locations must be determined, along with the SKU-to-location assignment which will influence order picking costs.

For LA2, there are seven possible paths through the storage function; three possible ways for a SKU carton to appear in a push order (from pallet rack, floor store or pallet gravity flow rack) and four possible ways for an each to appear in a pull order (from pallet rack, floor store, pallet gravity flow rack or carton shelf store). The decisions assigning SKUs to reserve store and forward pick zone, along with order profiles, will determine the flow rates on these seven paths. For LA2 there are additional flows for replenishing the two forward pick zones. Again, the sizing of each of the four storage functions is required, as well as SKU-to-location assignments.

It is at this point in the design process that optimization and simulation can play a major role in supporting design decisions.

A final note: the assignment of SKU to forward pick should not be static. For example, when a high volume SKU arrives, it might be assigned to pallet gravity flow rack for some period of time (regardless of its reserve assignment) and then removed when the rate of push order shipment declines. Similarly for SKUs assigned to carton shelf storage. This means that the final design must include operating policies or rules for making and rescinding the assignments to the forward pick zones (and associated SKU-to-location assignments).