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DLA Subsistence Network (SUBNET) Visualization/ Modeling & Simulation of the Subsistence Supply Chain

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Section 1 – Project Overview

In April 2019 Bättra LLC was awarded a cost plus contract under DLA’s Subsistence Network (SUBNET) R&D program to develop an in-house, flexible framework and technology backbone to store and manage supply chain data and demonstrate the capability to use the information to support wide ranging visualizations, What-If analyses for disaster/contingency planning, Supply Chain Risk Management (SCRM) activities, and more advanced M&S studies. Bättra partnered with RAAD360, LLC to extend its end-to-end Supply Chain Risk Management (SCRM) software platform in order to integrate existing DLA Subsistence industrial base data and create supply chain visualizations through a searchable and filterable geographic information system (GIS) interface.

The team developed an Advanced Process Data Management (APDM) Module to optionally store and manage, more detailed process level supplier data in order to estimate lead time and output capabilities during a national mobilization in support of the Warfighter. The module allows a DLA Industrial Specialist (IS) to create unlimited process level changes to model an increase in capability as a facility expands production to meet surge requirements, e.g. increased scheduled time, additional production (location) units, etc. For example, an IS may want to increase production at certain processes each month, based on the supplier’s surge plan. These time phased process inputs can be used to estimate an item’s 180-day surge and sustainment capability for industrial base planning purposes. Although the module was developed to manage detailed Meals Ready to Eat (MRE) production processes, the supply chain data model has the flexibility to be used in support of any industry, e.g. weapon system repair parts.

The team worked closely with AmeriQual Group, LLC (“AmeriQual”) to obtain MRE assembly data to include subtier suppliers to demonstrate the ability to 1) visualize an extended, multi-tier supply chain and support SCRM assessments within the system and 2) export data to a user’s discrete event simulation software application to support advanced supply chain analysis or Surge & Sustainment (S&S) planning. This project provides a standardized model to organize supply chain data and increases the speed at which DLA Subsistence can use the data to support various analytical insights.

Section 2 – Advanced Process Data Management (APDM) Module

The Advanced Process Data Management Module provides DLA a means to optionally store and manage, more detailed process level supplier data. DLA's industrial base provides the detailed process level data, which is organized by DLA IS's and entered into the RAAD360 system via a user interface or MS Excel upload utility. Once loaded into the system, the DLA IS can update the information as changes occur in the industrial base.

2.1 Process Data Overview

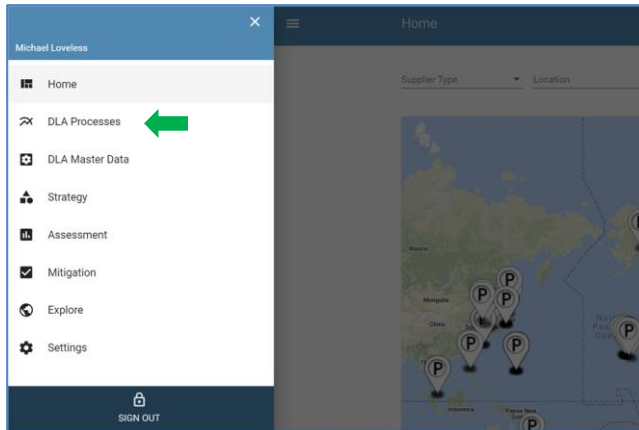
The process data framework is organized by the following modeling elements:

- **Locations**: Locations represent places where entities are routed for processing, storage, or some other activity or decision making.
- **Entities**: Entities flow through locations according to defined processes and resource requirements.¹ Entities can be joined at certain process locations with another component or material.
- **Process Groups/ Processes**: An entity can have more than one processing location with different capacities and processing speeds. A process group allows the user to define a process group name and associate various non-identical locations that perform the same processing of an input entity that yields the same output entity. Process Groups are linked together by 1) a routing number for each process combined with a routing entity, e.g. Bushing Assembly @ Process Routing #2 follows Bushing Assembly at Process Routing #1 OR 2) an upstream entity is joined to the Process Group as a joined entity – combined/ utilized during the production process.
- **Processes**: A Process Group may have one processing location or multiple, non-identical production locations, e.g. MRE fill lines. These locations are stored as processes with unique capacity and lead time metrics.

The module supports several key analytics for industrial base analysis – item lead times and process level constraints. The system will be able to identify the critical path of product/ manufacturing streams or the longest path required to finish the end item. Process data is utilized to estimate the maximum production capability at each process. Then, the minimum capacity process can be identified across all processes related to the item, which constrains maximum production (bottleneck). Lead time and process level constraints across the entire system can be modeled for changes from Day 1 to 180.

¹ Once exported to ProModel, entities can have attributes that are assigned to them to control how the model performs, e.g. product type, shelf life, unique processing requirements.

Figure 2.1: DLA Processes Button



The process data is organized by facility locations, which can be associated with one or more parent entities to form the extended supply chain. The processing facility is connected to upstream suppliers via the input/ output entity and routing number relationships. A user clicks on the DLA Processes button on the application’s landing page to access the process level data based on certain user privileges, as shown in Figure 2.1. Other means to access the process data module can in subsequent development phases through quick links on supplier pins via the mapping interface if process data exists.

2.2 Core Database Tables

This section provides an overview of the core database tables. Specific field names and related information has been provided in Appendix A – APDM Data Tables & Fields.

Table	Description
Project	Allows users to create supply chain process records related to a single project to facilitate data management, e.g. confidentiality restrictions and data review dates.
Parent	Stores information on unique organizational entities, e.g. corporation, that have one or more facilities where processes occur.
Facility	Stores information on distinct manufacturing locations where processes occur. A facility can only have one parent.
Location	Stores information on manufacturing locations within a facility and scheduled time characteristics. A location can only have one facility.
Item	Stores product information on the finished DLA item.
Entity	Stores information on entities processed within a facility and the extended supply chain. An entity is associated with an Item, Process Groups, and Join relationships.
Process Group	The Process Group table stores key process level information, such as process name, input and output entities, and Entity Conversion Factor (ECF). In contrast to a ProModel process, this module will not capture the destination location within the facility. To reduce the data requirements, users will connect processes using 1) a process routing number and routing entity relationship (e.g. Bushing Assembly @ Process Routing #2 follows Bushing Assembly at Process Routing #1) Or 2) Joining an upstream entity utilized at the process. There may be duplicate process routing numbers, but not in combination with a routing entity, similar to a primary key.
Process	Stores unique, non-identical processing locations for a process and related capability metrics. Also stores surge information for capacity constrained “Work” processes. More than one surge record can be associated with a unique “Work” process, e.g. @ Process #6, daily capacity increases from 12 to 16 units starting on Day 45, increasing again to 18 units on Day 70. The Process table has a relationship with the Process Group table.
Join	Stores entities that are joined at a process, e.g. BOM materials/ components and/ or one or more internally produced components within the facility. This table has relationships with a Process Group and an Entity.

2.3 Data Entry and Upload

To manage the data within the APDM, projects are created by clicking on the DLA Master Data button, as shown in Figure 2.2. Currently users can add Projects, Parents, Facilities, Locations, Items, and Entities directly into the application; however, the process level data (Process Group and Process) must be sent to the RAAD360 team to be loaded into the application via the backend. The team is considering the development of an MS Excel upload template and utility to make it easier for users to upload their models, while also providing front end functionality to edit/manage data. In addition, the upload utility will include testing functionality to check for common relationship errors, e.g. identification of joined entities not associated with a Process Group or a Process Group minimum start day that is greater than the minimum start day for the next downstream Process Group.

Figure 2.2: DLA Master Data

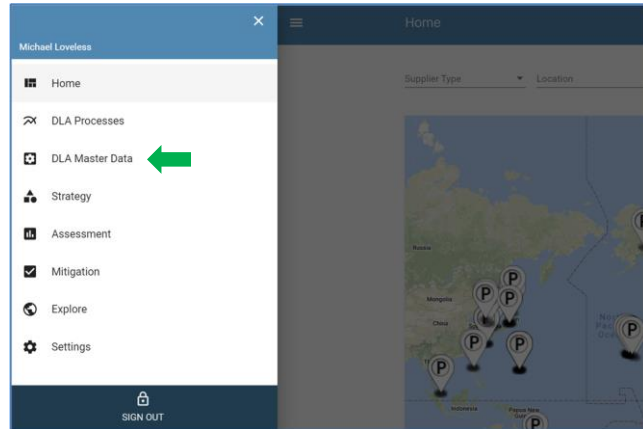


Figure 2.3: Project Data

Field	Description
Project Name	User defined name.
Project ID	System created project ID.
Project Description	Short description can be added to explain the scope/items involved.
User ID	Stores user name or ID.
Confidential	Yes/No; A "Yes" entry prevents any other users from seeing the underlying process records; only the overall supply chain analytics can be viewed, e.g. 180-day surge output and critical path lead time.
Review Date	Updating the Review Date indicates the user has reviewed the process data and ensures the data is currently accurate after engagement with industry stakeholders. Review dates should be conditionally rated to allow users to understand the age of the data and potential accuracy. A Review Date within the last 2 years (<= 2 years) will be given a "Green" format; "Yellow" for greater than 2 years, but less than or equal to 4 years; and "Red" for greater than 4 years.

The project data is linked relationally to all tables within the APDM to store Project_ID. Consequently, the user can also delete associated records by deleting a Project_ID from the Project table.

Parent – Facility – Location Information: The DLA user first adds the facility’s parent level information into the application, unless it already exists. Then all facilities are added related to production of the product, including sub-tier suppliers, unless they also already exist. The user will need to ensure that parents or facilities that are added are not duplicative, as some suppliers may not have a CAGE or DUNS readily available. Finally, for facilities that will be analyzed at the process level, individual locations within the plant, e.g. Lathe 1, are added related to the facility, including scheduled time data and location type, e.g. Work, LT Only.

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Item – Entity Information: After the location data has been entered, the DLA user will look-up the end item (e.g. MRE or UGR NIIN) or add the product, if it does not already exist in the system. For the first version of the application, the user will add items manually. Then the user will add all the entities that are within scope of the supply chain analysis and related to manufacturing the DLA end item product. The entities are later associated in a process relationship.

Note: Currently the process level data must be entered by the RAAD360 team via the backend. Future enhancements to the system are expected to provide a front end with the following data input functionality. In the meantime, users can organize their supply chain models according to the following guidance in Excel templates available for distribution:

Process Information: The user will enter the end item product, input and routing entities (if different) for the starting process using lookups. The end item product is used to facilitate filtered lookups for entities used in the process level data. Additional fields can be added to the user interface to display more information on the selected products, entities, and locations to give the user situational awareness, e.g. product/ entity name, location scheduled time, location type etc.

The **Routing Number** will be set automatically to 1 for the first process and incremented by 1 for each new process group created. The routing number can be changed manually, if processes are added out of order. If a new routing entity is added for a new process, then the routing number resets to 1. For example, if the process utilizes 1) BOM materials/ components and/ or 2) one or more internally produced components within the facility, the user will use a drop-down menu to select one or more **Joined Entities** at the process. This creates the relationships that are used by the critical path and capacity analysis and links upstream processes and/ or sub-tier suppliers to the facility. The **View Order** field can be used to manually order the Process Groups in a user desired flow.

If the routing entity has a one-to-one relationship with the end item product, then the **Entity Conversion Factor** is set to 1. For example, one routing entity is manufactured, which is equivalent to one finished end item. In other cases, it may take more than one routing entity to make an end item product, e.g. it may take 2 routing entities to make 1 end item product. In this case, the user would enter 2 for this field. This field ensures the process level production capability can be translated to the end item product, e.g. the process must produce twice as much to equal output of processes with a one-to-one relationship.

The user can also enter **Process Notes** for the Process Group to collect any relevant information about the process that is helpful in understanding how the work is completed.

The data entry process will also have a **Routing Information** section with the following fields.

- **Routing Entity** – User will use a drop-down menu to select the routing or input entity.
- **Output Quantity** – User enters the number of units of the output entity exiting the process. This should default to 1.
- **Routing Method** – User enters the method to move the output entity to the next process; example: "NA"; "Roller Conveyor"; "Automatic Conveyor"; "Forktruck"; "Cart"; "Automatic Guided Vehicle (AGV)"; "Crane"; "Robot"; "TL"; "LTL"; "Air"; "Other". This can be a pre-defined field list that allows edits.

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Within the Process level detail interface, the user will add the specific manufacturing location(s) using a lookup. This step creates the relationship of the Process Group to a facility. The user will add the **Changeover** and **Cycle time** information, based on data collected from industry. **Process Capacity** is entered. In many cases, this is 1 unit, but in other cases, production equipment may have the capacity to process more than one unit at a time, e.g. 5.

Furthermore, manufacturers often produce in batches that move through the facility. Typically, this means each unit within the batch is manufactured for the full unit cycle time, and the batch remains at the location until all items have been manufactured before moving to the next process. The user will enter the **Production Batch Size**, which often remains the same throughout most processes. As new process records are created for a “Work” location type, the system will copy the process batch size from the previous process record, while other location types should default to 1. Process capacity and production batch size are used together to estimate daily production output accurately with changeover and cycle time information.

Surge Information: The user can create one or more surge records for all processes via the Process interface. For example, the user may decide to increase the scheduled time for a machine based on moving from 1 to 2 shifts. The user would enter the new production hours per week and production days per week to increase the daily capacity. More than one surge record can be associated with a unique, non-identical location to capture changes over time during a surge event, e.g. Location #1 produces 100 units per production cycle from days 1-40 and then shifts to 150 units per cycle from days 41-180.

Note: ProModel location capacities are locked down when the model runs and cannot be changed dynamically during the run. Dynamic surge changes can be simulated by using ProModel’s Called Downtime commands for specific location units or routing entities to entirely different locations with additional capacity at different times during the simulation run (replicating the same process, but with more capacity). To estimate maximum output correctly, the surge data must be entered with fixed capacity by location with specified start and end dates.

2.4 Process Calculations

The process data will need to lookup location type to support the following process calculations:

- **Process Lead Time (Days):**
 - This calculation is the time it takes for the process to complete a full production run and is adjusted to account for non-production days during a production week, e.g. 5 production weekdays out of 7.
 - **Formula** – $((\text{Cycle Time in minutes} * (\text{Production Batch Size} / \text{Adjusted Batch Size})^2) + \text{Changeover Time in minutes}) / (\text{Scheduled Time in minutes} * (\text{Location Days per Week} / 7))$
 - **Example 1:** $((.75 \text{ min} * (100 / 1)) + 240 \text{ min}) / (960 \text{ min} * (5 / 7)) = 0.5 \text{ days}$

² Adjusted batch size is calculated based on Production Batch Size / Minimum of Production Batch Size or Process Capacity.

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- Example 2: $((2,880 \text{ min} * (1 / 1)) + 0 \text{ min}) / (1440 \text{ min} * (7 / 7)) = 2 \text{ days}$
- **Production Runs per Day:**
 - This field is only calculated for “Work” locations.
 - Formula – $1440 \text{ Mins} / (\text{Adj. Process Lead Time (Days)} * 24 \text{ Hrs} * 60 \text{ Mins})$
 - Example 1: $1440 \text{ minutes} / 960 \text{ minutes} = 1.3 \text{ production runs per day}$
 - Example 2: $1440 \text{ minutes} / 340 \text{ minutes} = 4.2 \text{ production runs per day}$
- **Maximum Daily Output:**
 - This field is only calculated for “Work” locations.
 - Formula – $\text{Adj. Production Runs per Day} * \text{Production Batch Size} * \text{Location Units} / \text{Entity Conversion Factor}$
 - Example 1: $1.3 * 100 / 2 = 65 \text{ units per day}$
 - Example 2: $2.8 * 100 / 1 = 280 \text{ units per day}$
- **ProModel Location Capacity:**
 - Formula – For “Work” locations, $\text{Process Lead Time (Days)} * \text{Adjusted Maximum Daily Output}$; If Else, “INF”
 - Example 1: $0.0255 \text{ days} * 1,959 \text{ units} = 50 \text{ units}$
 - Example 2: $20 \text{ days} * 36 = 720 \text{ units}$

These calculations will be stored in the Process table to support process analysis queries.

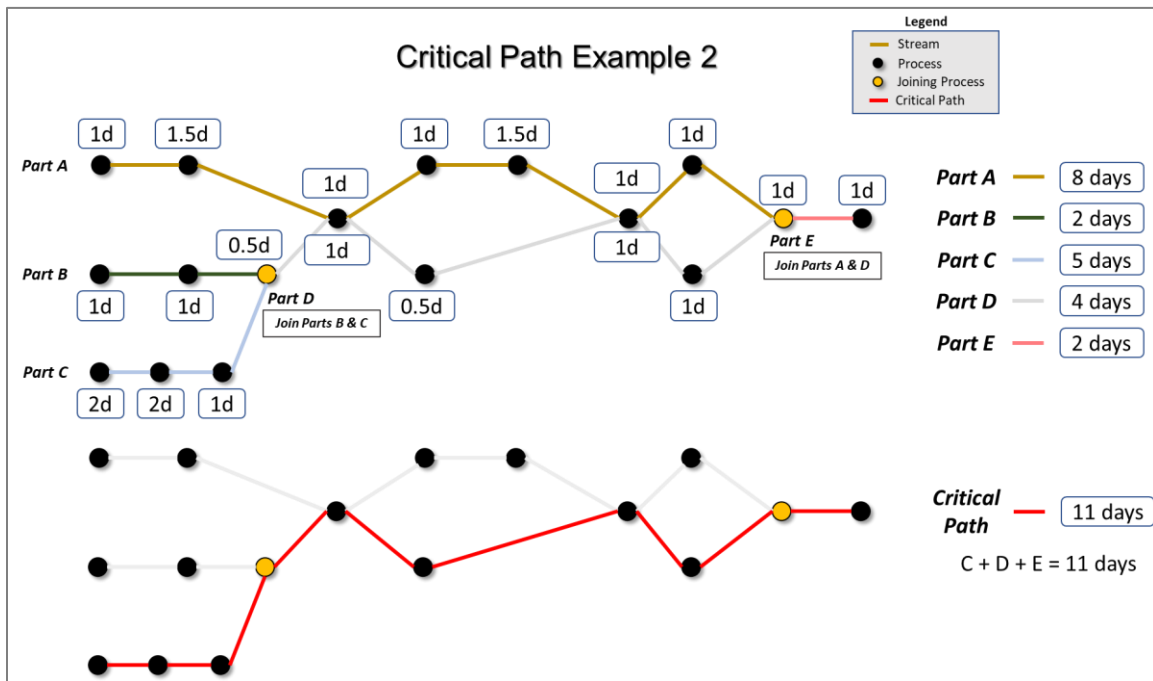
Section 3 – Supply Chain Analysis & Visualizations

This provides more information on the critical path and constraints analysis and visualizations developed in the application.

3.1 Critical Path Analysis

The application identifies the critical path of product streams or the longest path required to finish the end item. Figure 3.1 shows a graphical example of a manufacturing critical path.

Figure 3.1: Example Critical Path Analysis



The process starts with the manufacturing of three parts (A, B, C). Parts B and C are joined after several days to create Part D. Parts A and D are later joined together to form Part E. To identify the critical path, you have to identify the maximum lead time of the product streams that create the final part. The following are the three distinct streams:

- Part A to Part E = Total 10 days
- Part B to Part D to Part E = Total 8 days
- Part C to Part D to Part E = Total 11 days

Stream C-D-E has the longest lead time of 11 days and is the critical path for the final product, as shown in Figure 3.2.

Figure 3.2: Sample Critical Path Analysis of Entity Relationships

Level 1	Level 2	Level 3
Part A	Part E	NA
Part B	Part D	Part E
Part C	Part D	Part E
8 days	2 days	NA
2 days	4 days	2 days
5 days	4 days	2 days

Application logic has been created to automate this analysis. It begins with each Process Group and searches for all unique downstream relationships through the input/ routing and joined entity relationships. Figure 3.3 provides an example of the downstream relationship logic for the Mixing Process Group. The logic finds 4 levels of relationships downstream of Mixing, ending with the final Process Group of Casing. The logic is not limited by a maximum relationship level.

Figure 3.3: Relationship Logic Results for Mixing Process Group

Item_ID	Lvl1_Facility	Lvl1_PG_ID	Lvl1_Process	Level	Lvl_Facility_II	Lvl_PG_ID	Lvl_Process_I
1	1	1	Mixing	1	1	1	2 Filling
1	1	1	Mixing	2	1	1	3 Retort
1	1	1	Mixing	3	1	1	4 MRE Assembly
1	1	1	Mixing	4	1	1	5 Casing

Using a series of queries, the application logic sums the lead time data for each subsequent Process Group in a downstream relationship to determine the time to finish the item (1.2255 days for Mixing) on each surge day as shown in Figure 3.4. This value is then added to the starting Process Group's lead time to calculate the time it takes to finish the item (0.0458 + 1.2255 days = 1.2713 days for Mixing once the process starts).

Figure 3.4: Relationship Logic Results for Mixing Process Group

2 Filling	100 Pouch, Filled	1	0.0821
3 Retort	100 Pouch, Filled	2	0.1172
4 MRE Assembly	104 MRE_Meal	1	0.0262
5 Casing	105 MRE_Case	1	1.0000

Subsequent queries identify the longest lead times by manufacturing streams by item and facility.

3.2 Process Constraints Analysis

The module also analyzes process data to estimate the maximum daily production capability at each process, and then identifying the minimum capacity process, which constrains maximum

production (bottleneck). The Process table has calculated fields that assess the process data entered and calculate the process output per production run and the lead time in days.

The analytics identify an item’s 180-day surge output, based on the process that has the minimum 180-day output quantity relative to all other processes independent of constraints upstream or downstream – assumes process never runs out of materials/ components to produce and is never blocked by limited capacity downstream. The model estimates the output day by determining the time it takes to complete final production of the end item from every process step for each surge day (1-180), which allows the model to dynamically incorporate changes in lead times during a surge event, e.g. lead time at a process drops from 20 to 10 days after 45 days. Each process’s output is stated in terms of output day, which maybe several days or weeks after a production run has been completed at a specific process step.

Note: The model will not analyze changes to process routings or relationships during a surge; only lead time and process output can be changed over time. Process relationships are locked down on day 1 based on the Process table.

The analytical model utilizes application logic to create surge records for surge and non-surge processes. Starting with the dynamic surge records, it uses “While Do” loops to create the process output records for each surge period and each unique, non-identical location – surge output can be estimated for a single process or multiple locations for the same process, e.g. Autoclave 1 and Autoclave 2.

For processes that have more than 1 production run per day, output is determined by multiplying the process’ Production Runs per Day * Capacity to estimate daily production. For processes with less than 1 production run per day, output is based on capacity after every lead time interval.

The following example explains how the logic works for surge records for processes with less than 1 production run per day:

Figure 3.5: Illustrative Surge Records Entered for Process #23 for 3 Locations

Process_ID ↕	StartDay ↕	EndDay ↕	LeadTime ↕	Capacity ↕	LocUnit ↕
23	1	41	20	160	1
23	42	76	15	160	1
23	77	180	10	160	1
23	42	76	15	60	2
23	77	180	10	60	2
23	77	180	10	60	3

Process #23 has 3 process locations. During a surge, Location #1 (LocUnit =1) produces 160 units every 20 days. On Day 42, any new production runs at Location # 1 have a shorter processing lead time of 15 days. On Day 77, lead time drops to 10 days. For this process location, the logic creates the following surge records for Location #1:

Figure 3.6: Surge Records Created for Location #1

Item_ID	Process_ID	SrgeDay	Cap
1	23	20	160
1	23	40	160
1	23	60	160
1	23	75	160
1	23	90	160
1	23	100	160
1	23	110	160
1	23	120	160
1	23	130	160
1	23	140	160
1	23	150	160
1	23	160	160
1	23	170	160
1	23	180	160

The application logic calculates 3 production runs at the 20-day lead time by dividing 41 days in the 1st surge period by the lead time of 20, which is equal to 2.05 production runs. The logic rounds this up to 3 production runs during the 1st surge period and creates surge records for Days 20, 40, and 60 for 160 units respectively. After production on Day 60, a new reduced lead time of 15 days is in effect for Location #1. The logic determines the remaining time in this 2nd surge period (76 days – 60 days = 16 days). The logic calculates 1.07 production runs during the 2nd surge period and rounds this up to 2 production runs. Surge records are created for Day 75 and 90 for 160 units respectively. After production on Day 90, a new reduced lead time of 10 days is in effect for Location #1. The logic determines the remaining time in this 3rd surge period (180 days – 90 days = 90 days). The logic calculates 9 production runs and creates surge records for Days 90 through 180 with 10-day intervals each for 160 units respectively.

After surge records are created for Location #1, the logic moves to the next record for Location #2, which has 60 additional units of capacity that comes on-line on Day 42 with a process lead time of 15 days. The logic calculates 3 production runs by dividing 35 days in the 1st surge period by the lead time of 15, which is equal to 2.33 production runs. The logic rounds this to 3 production runs and creates surge records for Days 56 (42 - 1 + 15), 71 (56 + 15), and 86 (71 + 15) for 60 units respectively.

After production on Day 86, a new reduced lead time of 10 days is in effect for Location #2. The logic determines the remaining time in this 2nd surge period (180 days – 86 days = 94 days). The logic calculates 9.5 production runs and creates 10 surge records for Days 96 through 186 with 10-day intervals each for 60 units respectively.

Finally, after surge records are created for Location #2, the logic moves to the next record for Location #3, which also has 60 additional units of capacity that comes on-line on Day 77 with a process lead time of 10 days. The logic calculates the number of days within this one and only surge period (180 days – 71 days = 109 days). The logic calculates 10.9 production runs

and creates 11 surge records for Days 86 (72 - 1 + 15) through 186 with 10-day intervals each for 60 units respectively.

Figure 3.7: Surge Records Created for Locations #2 & 3

Item_ID	Process_ID	SrgeDay	Cap
1	23	116	60
1	23	126	60
1	23	126	60
1	23	136	60
1	23	136	60
1	23	146	60
1	23	146	60
1	23	156	60
1	23	156	60
1	23	166	60
1	23	166	60
1	23	176	60
1	23	176	60
1	23	186	60
1	23	186	60

3.3 Supply Chain Flow Visualization

The following sections describe the functionality developed to show *Item* level supply chain flow visualizations and estimate Process Group, Facility, and Item level lead time and capacity estimates along a 180-day surge day slider.

Figure 3.8 displays the application’s **critical path** visualization of the MRE supply chain data utilized in the pilot project. The **red** flow line – *Production, Bakery, Filled, Apple Turnover & Cinnamon Bun (Bridgford Foods) to AmeriQual’s MRE Assembly Process Group* – indicates the critical path created by moving Bridgford’s production lead time to 21 days, exceeding the lead time of all over assembly components for illustration purposes. On Day 1 of the 180-day surge slider, the total lead time of the critical path on that day is 24.1 days until a finished MRE case is produced. The slider can be moved to visualize changes that may be encountered if the critical path shifts to a new manufacturing stream over time. Facility level visualization functionality that has been developed for this project, but not implemented can be incorporated into the application in the future. This functionality would allow the user to see the total time it takes for a product to be completed at a facility over time.

Similarly, Figure 3.9 displays the application’s **process constraints** visualization. The **red** flow line – *Receiving to Mixing to Filling to Retort to MRE Assembly to Casing* – indicates the supply chain’s constrained capacity. On Day 61 of the 180-day surge slider, maximum daily output increases from 9,659.8 (*MRE Assembly can start once the Apple Turnover & Cinnamon Bun are received after 21 days*) to 22,565.3 cases as production equipment moves over to MREs. The slider can be moved to visualize changes, if the constraint shifts to a new manufacturing stream over time. Likewise, facility level visualization functionality developed for this project, but not implemented, would allow the user to see the maximum daily output of each facility over time.

Figure 3.8: MRE Supply Chain Flow Visualization of Critical Path

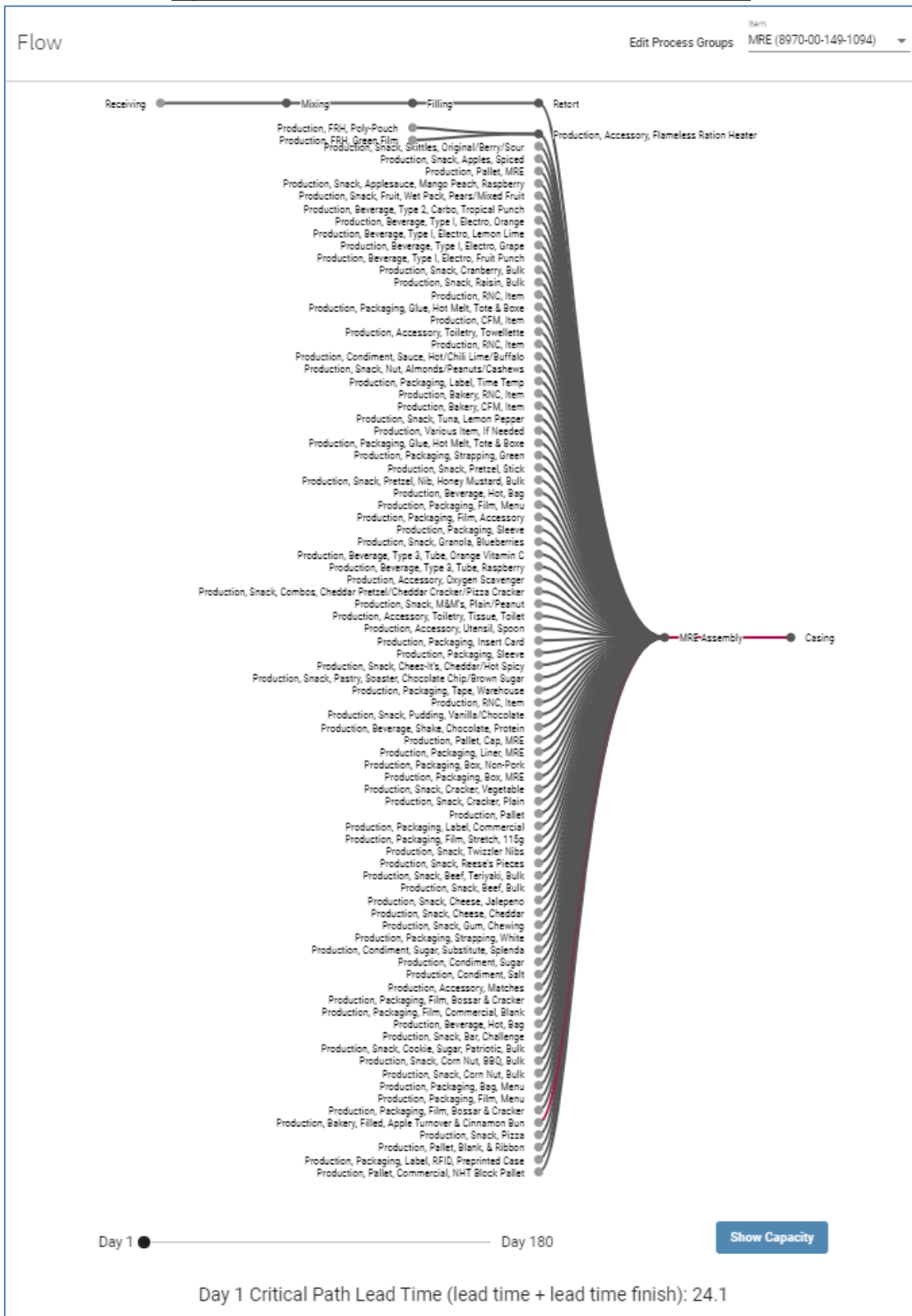
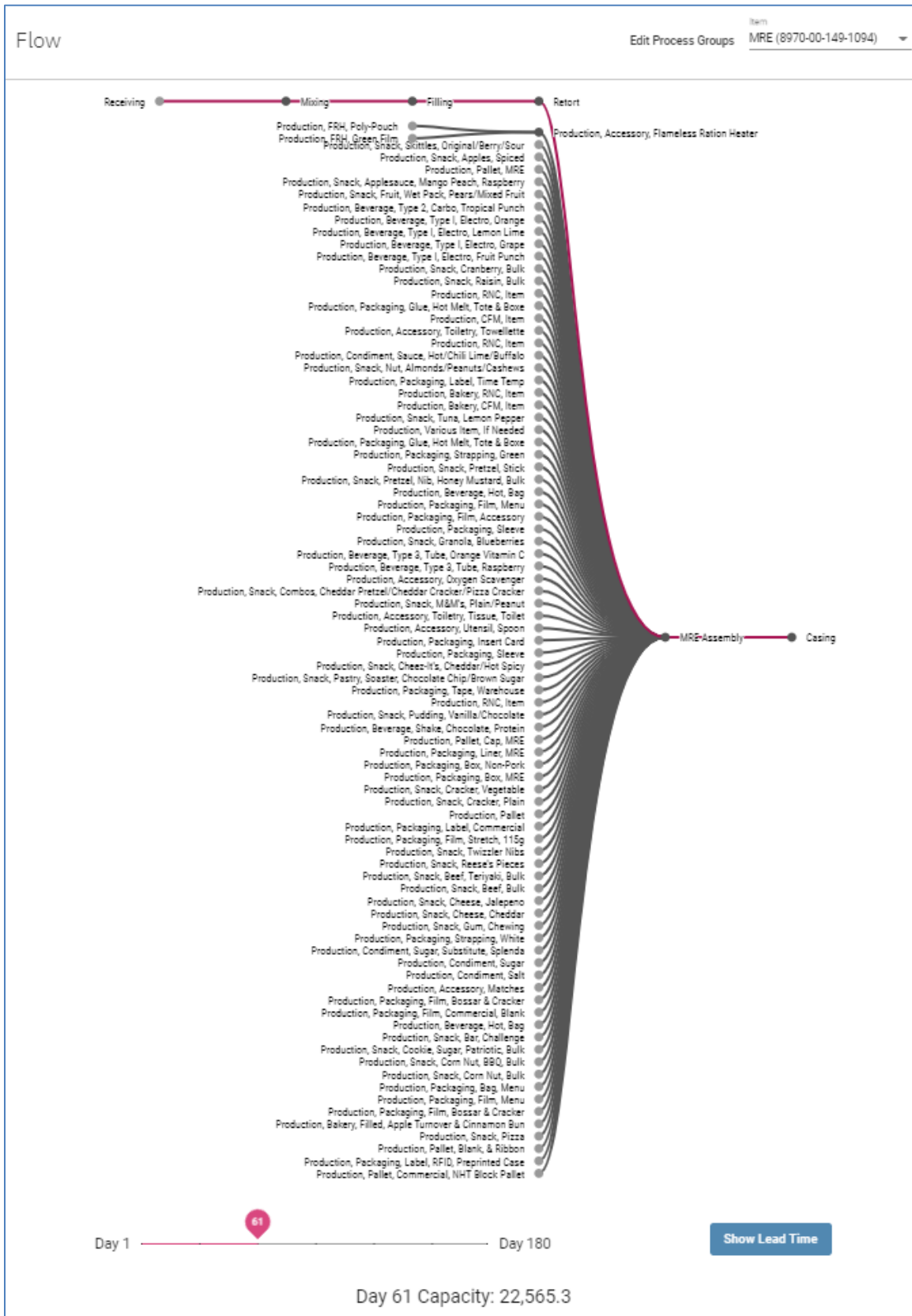


Figure 3.9: MRE Supply Chain Flow Visualization of Capacity Constraints



3.4 Process Data Export to ProModel ProActiveX Template

The module has functionality to export RAAD360 process data to ProModel's ProActiveX Template (MS Excel) to support more advanced analysis using discrete event simulation software. The exported data allows a modeler to quickly develop a baseline model without surge scenarios.³ The functionality creates all of the ProModel process records with related input and routing entities, including Work-in-Progress (WIP) In and Out locations for each "Work" process. It also creates unique Facility/Location names to help modelers better navigate records associated with complex manufacturing environments and supply chains and removes any unallowed characters, e.g. spaces and periods in names. Finally, the functionality creates logic for WAIT and JOIN commands for the baseline model.

The modeler must have the following prerequisites:

- Most recent version of ProModel (ProModel 2018 – Professional),
- ProActiveX template from the ProModel Corporation PowerTools folder, and
- MS Excel for Office 32-bit.⁴

The application has core simulation data that can be configured as needed, but is consistently used in most models. These starting configurations can be updated and customized using the ProModel application after the process data has been imported from the template. The following tables hold various modeling elements:

- **PM Core Arrays**: Starting MS Excel Arrays associated with the process data.
- **PM Core Arrival**: Arrival records to run a baseline model without surge scenarios; includes administrative daily, weekly, and monthly entities used in processes to enable model functions.
- **PM Core Attribute**: Commonly used attributes.
- **PM Core Ent**: Commonly used entities for a DLA Order for a baseline model without surge, includes administrative entities.
- **PM Core ExtFiles**: External files associated with MS Excel Arrays.
- **PM Core Loc**: Administrative location commonly used to enable model functions and ordering.
- **PM Core Macros**: Placeholder; none added for simple baseline model.
- **PM Core Process**: Process records to run a baseline model without surge scenarios; includes administrative daily, weekly, and monthly processes to enable model functions.
- **PM Core Subroutines**: Roundup and Rounddown subroutines commonly used in model development.

³ **Note:** There are various modeling approaches to simulate surge that are best left for development in ProModel's application.

⁴ ProModel does not offer a 64-bit template.

- **PM Core Var:** Commonly used variables for measuring output over time and PLT.

The user selects a Project that has associated process records entered into the RAAD360 system and clicks on an export button that uses a series of queries and logic to add records to the ProActiveX template for the selected project. The application asks the modeler to click on the file path for ProActive X template, and then prepares the modeling data.

After the process data has been prepared, the VBA uses a “While Do” loop to add all core (configured) and user added custom records in the appropriate ProActiveX template worksheet using a row and column reference.⁵ Finally, the application asks the modeler to select the file path to store the newly created template name (the logic adds “new” to the ProActiveX template name).

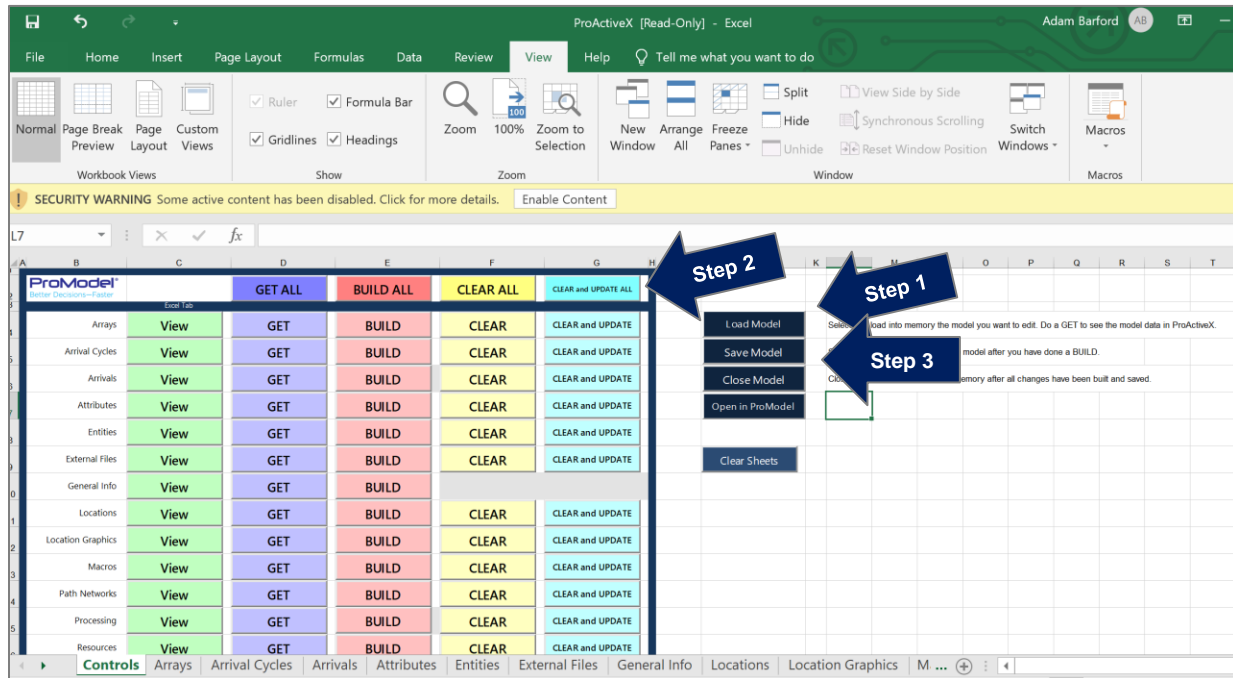
Step 1: To export the data into ProModel, the modeler first creates a new model in the ProModel application, saves, and closes it.

Step 2: The modeler opens the ProActiveX template, enables content (unless already enabled), and loads the model using the “Load Model” button on the right side of the Controls worksheet. A message will appear stating that the model is loaded and ready for editing.

Step 3: The modeler next clicks on the “Clear and Update All” button, which clears out any existing model records in the loaded model and loads the exported data from the template. A message will appear stating that model has been updated.

Step 4: Finally, the modeler clicks on the “Save” and “Close” buttons, and then can open the model using the “Open in ProModel” button to view and run the simulation.

Figure 3.10: ProModel’s ProActiveX Template Controls Worksheet



⁵ Simulation options worksheet adds data to several named form text box controls instead of a cell.

Section 4 – DLA Subsistence Data Management

This section provides an overview of the procedures required to export DLA Subsistence data from the Enterprise Data Warehouse (EDW). This data is used within RAAD360's system to support visualizations using a mapping interface.

4.1 DLA Subsistence Data

The core data is sourced from the following DLA EDW tables using SAS Studio:

- DORRADW_MATL_MASTER_DIMENSION (Item level data):
 - Criterion: SUP_CHAIN = "SUBS"
 - Exported as SUBMM csv file
- CV_PR_BPURHO02 (Purchase Order data):
 - Criterion: CREATEDON date is last 12 months
 - Exported as POVENDOR csv file
- DORRADW_BSM_VENDOR_ADDR_DIM (CAGE level data)
 - Criterion: Left join on list of unique CAGEs from POVENDOR table
 - Exported as CAGEADDR csv file

An MS Access database was developed to prepare the data for use in RAAD360's system. Market Fresh and Subsistence Prime Vendor data is sourced from DLA's Subsistence website⁶ and manually copied to MS Excel to merge with contract data from Purchase Orders in the MS Access database. Hyphens are removed from contract data before importing. Worksheets are imported as PV for Subsistence Prime Vendor and MF for Market Fresh.

The data imported into the RAAD360 system is intended to be refreshed and replaced entirely with new records each time. User added data to support mapping of the supply chain and capability analysis will not be overwritten. The 2 datasets are linked by CAGE or DUNS.

Note: Some suppliers (e.g. international) do not have a DUNS listed in the dataset.

4.2 Mapping Interface & Filters

All suppliers in the CAGE table will be plotted in the GIS interface within RAAD360's system using a simple pin schema:

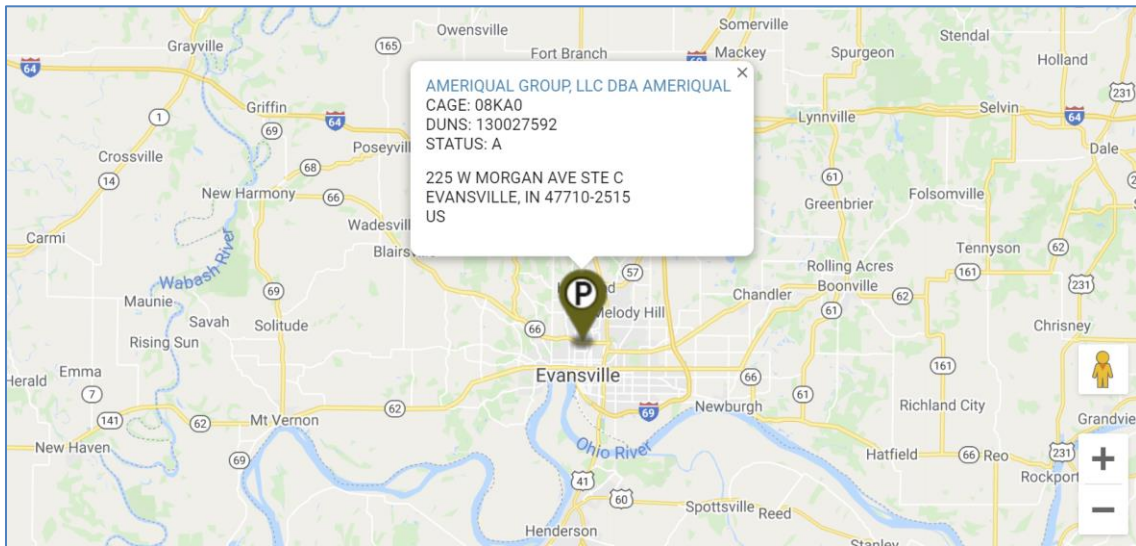
- Pin color of "Olive Drab" for any OPRAT vendor and "White" for any non-OPRAT vendor
- "P" for a prime vendor, "S" for a subtier vendor, or "B" for both a prime and subtier vendor.⁷

⁶ Website: <https://www.dla.mil/TroopSupport/Subsistence/Foodservices/Regions/CONUS.aspx>

⁷ In some cases, a vendor may serve as a prime and subtier supplier or serve in multiple subtiers. Therefore, adding a number to identify the tier may be too complicated.

After clicking on the pin, the supplier's Name, DUNS, CAGE, Address, City, State, ZIP, Country, and Status are displayed, as shown in Figure 4.1.

Figure 4.1: AmeriQual Group Pin Information



In addition, at the bottom of the screen, summary, contract and item level data are displayed. The Summary tab (Figure 4.2) has annual PO value (annual buys on a rolling 12-month basis), OPRAT Identifier (if applicable), SPV Region, and Market Fresh Region and Type. It also has the top 3 NIINs by annual PO value.

Figure 4.2: AmeriQual Group Summary Information

AMERIQUAL GROUP, LLC DBA AMERIQUAL OPRAT

DUNS: 130027592 | **CAGE:** 08KA0 | **STATUS:** A

225 W MORGAN AVE STE C
 EVANSVILLE, IN 47710-2515
 US

Summary
POs
Items

Net PO Value: \$181,943,373.00

SPV Region: –

MFV Region: –

MFV Type: –

Top Items

Name	NIIN	CAGE	Net PO Value
MEAL, READY-TO-EAT, IND,	001491094	08KA0	\$138,142,109.60
UGR A,D7,PERISHABLE	015256823	08KA0	\$2,151,603.13
UGR A,B3,PERISHABLE	015256733	08KA0	\$1,770,626.50

The POs tab (Figure 4.3) displays contract summary information by PIIN and PIIN type in descending order of annual PO value.

Figure 4.3: AmeriQual Group Contract Summary Information

AMERIQUAL GROUP, LLC DBA AMERIQUAL **OPRAT**

DUNS: 130027592 | CAGE: 08KA0 | STATUS: A

225 W MORGAN AVE STE C
EVANSVILLE, IN 47710-2515
US

Summary		POs	Items
Type	Contract	Net PO Value	
D	SPE3S117DZ113	\$138,159,272.48	
D	SPE3S118DZ208	\$14,834,126.13	
D	SPM3S113DZ187	\$5,241,238.76	
D	SPE3S118DZ723	\$2,895,474.70	
D	SPE3S118DZ721	\$2,311,998.72	
D	SPE3S118DZ716	\$1,901,924.34	
D	SPE3S118DZ711	\$1,555,754.84	
D	SPE3S118DZ709	\$1,491,925.83	
D	SPE3S118DZ714	\$1,160,231.42	
D	SPE3S114DZ700	\$1,094,233.44	
D	SPE3S118DZ702	\$1,086,003.76	

The Items tab (Figure 4.4) displays item information in descending order of annual PO value.

Figure 4.4: AmeriQual Group Item Summary Information

AMERIQUAL GROUP, LLC DBA AMERIQUAL **OPRAT**

DUNS: 130027592 | CAGE: 08KA0 | STATUS: A

225 W MORGAN AVE STE C
EVANSVILLE, IN 47710-2515
US

Summary		POs	Items	
Name	NIIN	CAGE	CAGE Name	Net PO Value
MEAL, READY-TO-EAT, IND,	001491094	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$138,142,109.60
UGR A,D7,PERISHABLE	015256823	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$2,151,603.13
UGR A,B3,PERISHABLE	015256733	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,770,626.50
UGR A,B2,SEMIPERISHABLE	015256366	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,721,213.78
UGR A,B5,PERISHABLE	015256739	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,485,844.13
UGR A,B4,SEMIPERISHABLE	015256372	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,480,168.74
UGR A,B1,SEMIPERISHABLE	015256344	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,467,822.65
UGR A,B3,SEMIPERISHABLE	015256370	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,421,436.04
UGR A,B6,SEMIPERISHABLE	015256389	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,418,292.26
UGR A,B6,PERISHABLE	015256740	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,402,310.59
UGR A,B5,SEMIPERISHABLE	015256377	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,280,086.15
UGR A,B7,SEMIPERISHABLE	015256720	08KA0	AMERIQUAL GROUP, LLC DBA AMERIQUAL	\$1,218,623.38

The mapping interface has the following filters (Figure 4.5) to display the supplier pins accordingly:

- **Supplier type:** OPRAT, SPV by region, Market Fresh vendor by region and type.
- **Location:** Multiple states and countries.

Figure 4.6: Surge Test Functionality

SYSCO RALEIGH, LLC DBA SYSCO FOOD

DUNS: 159868624 | CAGE: 4MF15 | STATUS: A

1032 BAUGH RD
 SELMA, NC 27576-9105
 US

Summary POs Items **Surge Test**

New Surge Test

1. Download the Surge Test Excel template.

DOWNLOAD

2. After filling in the surge test information, upload the completed Excel file.

UPLOAD

Surge Test Results

Date	Test 1 Score	Test 2 Score	Test 3 Score	Test 4 Score
12/29/2019	54.3%	59.0%	70.8%	77.1%
6/30/2019	40.5%	56.6%	64.8%	64.8%

The import template has 3 worksheets: Req, Cap, Sub (optional). These worksheets replace data in the following database tables:

- **SPV_TestReq**: Provides the Item level requirement. The table has 2 fields: Item and Req (numeric surge requirement). No duplicate items are allowed.

SPV_TestReq	
Item	Req
0001	10
0002	15
0003	20
0004	25
0005	30
*	0

- **SPV_TestCap**: Provides the supplier’s item level current inventory and due-in capability. The table has 3 fields: Item, Inv and Duein. No duplicate items are allowed and the capability needs to be stated in the same timeframe as the requirement, e.g. dueins within the same timeframe of the requirement.

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Item	Inv	Duein
0001	20	0
0002	10	5
0003	5	0
0004	10	4
0005	20	0
0006	2	0
0007	3	1
*	0	0

- SPV_TestSub:** Provides customer approved substitute items for an item with a surge requirement. This is an optional data table, if substitutes are allowed and documented. The table has 2 fields: Item and Item_Sub. The table can represent a substitute relationship as 2 records for the same substitute relationship (example: both ItemA to ItemB and ItemB to ItemA) without causing an error in the test.

Item	Item_Sub
0003	0006
0003	0007
0001	0003
*	

Using the Upload button, the application will create a new record in a table called “SPV_TestLog” and pulls in the supplier information.

Once the data is replaced, the following queries perform the surge test:

- SPV_Test1:** Prepares requirement and supplier capability data for testing. *Base tables/queries: SPV_TestReq, SPV_TestCap.*

Item	Req	Inv	Duein	InvDueins
0001	10	20	0	20
0002	15	10	5	15
0003	20	5	0	5
0004	25	10	4	14
0005	30	20	0	20

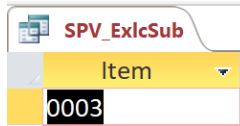
- SPV_ExclSubDup:** Eliminates duplicate substitutes that may have been entered. *Base tables/queries: SPV_TestSub.*

Item	Item_Sub
0001	0003
0003	0006
0003	0007

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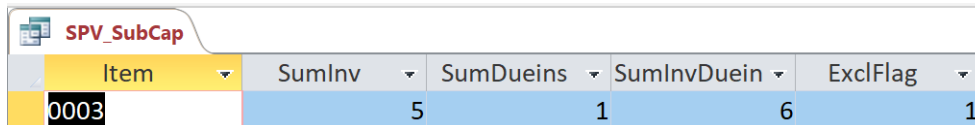
- **SPV_ExclSub:** Identifies items with requirements that are also listed as a substitute. *Base tables/queries: SPV_Test1, SPV_ExclSubDup.*



The screenshot shows a query titled "SPV_ExclSub" with a single column "Item" and one row containing the value "0003".

Item
0003

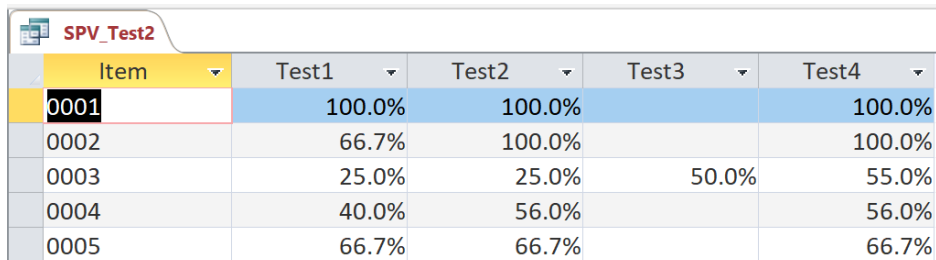
- **SPV_SubCap:** Sums up substitute inventory and due-in capability, but only for substitutes that do not also have a requirement to prevent overstating the capability. *Base tables/queries: SPV_Test1, SPV_ExclSubDup.*



The screenshot shows a query titled "SPV_SubCap" with columns "Item", "SumInv", "SumDueins", "SumInvDuein", and "ExclFlag". The row for item "0003" shows values 5, 1, 6, and 1 respectively.

Item	SumInv	SumDueins	SumInvDuein	ExclFlag
0003	5	1	6	1

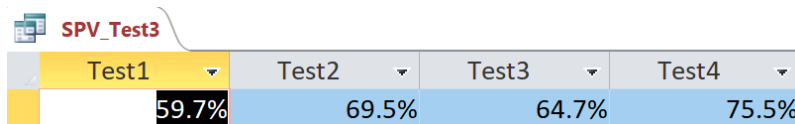
- **SPV_Test2:** This query performs 4 tests at the item level: Test1 tests inventory only, Test2 tests inventory and dueins, Test3 tests item and substitute inventory, and Test4 tests item and substitute inventory and dueins. *Base tables/queries: SPV_Test1, SPV_SubCap.*



The screenshot shows a query titled "SPV_Test2" with columns "Item", "Test1", "Test2", "Test3", and "Test4". The results are as follows:

Item	Test1	Test2	Test3	Test4
0001	100.0%	100.0%		100.0%
0002	66.7%	100.0%		100.0%
0003	25.0%	25.0%	50.0%	55.0%
0004	40.0%	56.0%		56.0%
0005	66.7%	66.7%		66.7%

- **SPV_Test3:** This query calculates the average test scores across all items. *Base tables/queries: SPV_Test2.*



The screenshot shows a query titled "SPV_Test3" with columns "Test1", "Test2", "Test3", and "Test4". The results are as follows:

Test1	Test2	Test3	Test4
59.7%	69.5%	64.7%	75.5%

Test 1 (Inventory Only – No Substitutes): This calculates the prime vendor's inventory capability vs. requirements.

Test 2 (Inventory & Due-ins – No Substitutes): This calculates the prime vendor's inventory and due-in capability vs. requirements.

Test 3 (Inventory Only – Includes Substitutes): This calculates the prime vendor's inventory capability, including substitute items, vs. requirements.

Test 4 (Inventory & Due-ins – Includes Substitutes): This calculates the prime vendor's inventory and due-in capability, including substitute items, vs. requirements.

Appendix A – APDM Data Tables & Fields

This section provides the tables and field names used in the APDM.

Appendix A.1 – Project Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Project_ID	Yes	AutoNumber	No Duplicates
Project_Name	No	Short Text	User defined name
Project_Desc	No	Short Text	Short description can be added to explain the scope/items involved
User_ID	No	Number	Stores user name or ID; linked to account info
Confidential	No	Yes/No	A “Yes” entry will prevent any other users from seeing the underlying process records
Rev_Date	No	Date	Updating the Review Date indicates the user has reviewed the process data and ensures the data is currently accurate after engagement with industry stakeholders. Review dates should be conditionally rated to allow users to understand the age of the data and potential accuracy. A Review Date within the last 2 years (<= 2 years) will be given a “Green” format; “Yellow” for greater than 2 years, but less than or equal to 4 years; and “Red” for greater than 4 years.

Appendix A.2 – Parent Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Parent_ID	Yes	AutoNumber	No Duplicates
DUNS	No	Short Text	No Duplicates
Parent_Name	No	Short Text	
Address	No	Short Text	
City	No	Short Text	
State	No	Short Text	Use a drop down menu
Zip_Code	No	Number	
Country	No	Short Text	Use a drop down menu
CAGE	No	Short Text	Optional
Data_Confidential	No	Yes/No	Access to process level data will be restricted, but high level capacity info will be displayed
POC_Name	No	Short Text	Optional
POC_Title	No	Short Text	Optional
POC_Phone	No	Short Text	Optional
POC_email	No	Hyperlink	Optional
website	No	Hyperlink	Optional

Appendix A.3 – Facility Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Facility_ID	Yes	AutoNumber	No Duplicates
Facility_Name	No	Short Text	

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Address	No	Short Text	
City	No	Short Text	
State	No	Short Text	Use a drop down menu
Zip_Code	No	Number	
Country	No	Short Text	Use a drop down menu
Parent_ID	No	Number	Link to Parent table
CAGE	No	Short Text	Optional
POC_Name	No	Short Text	Optional
POC_Title	No	Short Text	Optional
POC_Phone	No	Short Text	Optional
POC_email	No	Short Text	Optional

Appendix A.4 – Location Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Location_ID	Yes	AutoNumber	No Duplicates
Loc_Name	No	Short Text	
Other_Loc_Name	No	Short Text	Optional
Facility_ID	No	Number	Link to Facility table
Loc_Units	No	Number	Number identical location units (Production Equipment)
Hours_Wk	No	Number	Production hours per week
Days_Wk	No	Number	Production days per week
SchedTimeAdjust	No	Number	Adjusts scheduled daily time for multiple processes at shared locations
Loc_Notes	No	Long Text	Optional
Loc_Type	No	Short Text	Field List: Work, Work (Lead Time Only), Storage, External Supplier
Sched_Time	No	Calculated	$\text{Location_Units} * \text{Hours_Wk} / \text{Days_Wk} * 60 * \text{SchedTimeAdjust}$

Appendix A.5 – Item Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Item_ID	Yes	AutoNumber	No Duplicates
PartNumber	No	Short Text	NIIN
PartName	No	Short Text	NIIN Name
Other_Name	No	Short Text	Optional

Appendix A.6 – Entity Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Entity_ID	Yes	AutoNumber	No Duplicates
Entity_Name	No	Short Text	
Item_ID	No	Number	Link to Item table
BOM_Item	No	Yes/No	

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BOM_ratio	No	Number	Number of BOM units to 1 Product
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Appendix A.7 – Process Group Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Process_Group_ID	Yes	AutoNumber	No Duplicates
Process_Name	No	Short Text	User defined process group name
Facility_ID	No	Number	Link to Facility table
Item_ID	No	Number	Link to Item table
Entity_ID	No	Number	Link to Entity table; filtered list based on selected Item_ID
RouteNum	No	Number	Set to 1 for 1st process group and incremented by 1 for each new process group created; If a new input entity is added for new process group, then resets to 1; editable field
Process_Notes	No	Long Text	Optional
ECF	No	Number	Entity Conversion Factor; defaults to 1
Routing_Entity_ID	No	Number	Link to Entity table; filtered list based on selected Item_ID
Routing Method	No	Short Text	"NA";"Roller Conveyor";"Automatic Conveyor";"Forktruck";"Cart";"Automatic Guided Vehicle (AGV)";"Crane";"Robot";"TL";"LTL";"Air";"Other"
Output_Qty	No	Number	Defaults to 1
Logic	No	Short Text	ProModel field for storing optional process logic, e.g. Wait commands
LogicJoin	No	Short Text	ProModel field for storing optional Join logic
Rule	No	Short Text	ProModel field for routing rules; either "First Available" or "Join Request"
View_Order	No	Number	User defined order number to sort and view process groups

Appendix A.8 – Process Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Process_ID	Yes	AutoNumber	No Duplicates
Process_Group_ID	No	Number	Link to Process_Group table
StartDay	No	Number	Day capacity begins, e.g. 45 days
EndDay	No	Number	Day capacity begins, e.g. 77 days
Location_ID	No	Number	Link to Location table
Process_Notes	No	Long Text	Optional
CO_Time	No	Number	Defaults to 0
CO_Unit	No	Short Text	"Seconds";"Minutes";"Hours";"Days";"Weeks"
CO_Time_Min	No	Calculated	IF(Units = "Minutes", CO Time, IF(Units = "Hours", CO Time * 60, IF(Units = "Seconds", CO Time /60, IF(Units = "Days", CO Time * 24 * 60, IF(Units = "Weeks", CO Time * 7 * 24 * 60, CO Time * 30 * 24 * 60))))))
Process_Cap	No	Number	Defaults to 1; Processing capacity of location's production equipment in units, e.g. 2 at a time
Batch_Size	No	Number	Defaults to 1; copies from previous "Work" process on new record; set to 1 for non-Work location type
CT_Time	No	Number	Cycle time
CT_Unit	No	Short Text	"Seconds";"Minutes";"Hours";"Days";"Weeks"

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CT_Time_Min	No	Calculated	IF(Units = "Minutes", CT, IF(Units = "Hours", CT Time * 60, IF(Units = "Seconds", CT /60, IF(Units = "Days", CT * 24 * 60, IF(Units = "Weeks", CT * 7 * 24 * 60, CT * 30 * 24 * 60))))))
Loc_Units	No	Number	Number identical location units (Production Equipment)
Hours_Wk	No	Number	Production hours per week
Days_Wk	No	Number	Production days per week
LeadTime	No	Calculated	Process lead time in days
Capacity	No	Calculated	For "Work" locations only, Adj_Process_LT * MaxDailyOutput; Else If "INF"
Prod_Runs_Day	No	Calculated	Production Runs per Day
MaxDailyOutput	No	Calculated	Maximum Daily Output

Appendix A.9 – Join Table

FIELD NAME	PRIMARY KEY	DATA TYPE	DESCRIPTION
Join_ID	Yes	AutoNumber	
Process_ID	No	Number	Link to Process table
Entity_ID	No	Number	Link to Entity table