AEROSONIC

Level Load Tool Instructions

Updated: 8/17/2016

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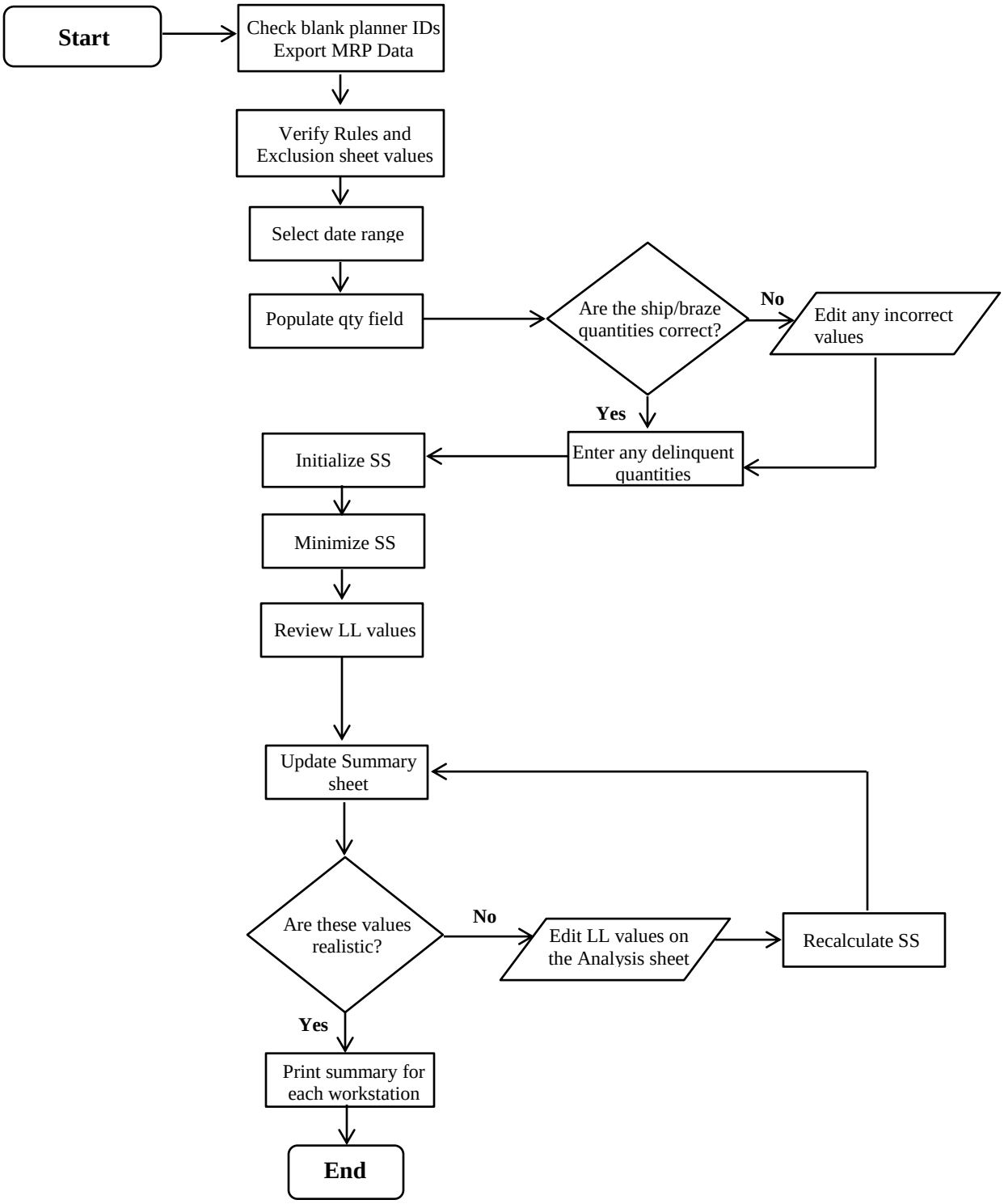
Overview

The purpose of this tool is to calculate a constant number of parts that must be built per day in order to meet customer demand in time, i.e., *the level load*. Production leveling helps to minimize fluctuation on the assembly line which, in turn, provides a more predictable and less erratic production system than the build-to-order model can. The objective of this document is serve as a tutorial by discussing the usage, processes, and mathematics of the tool. The flowchart below outlines the steps required by the user.



Updating the Data

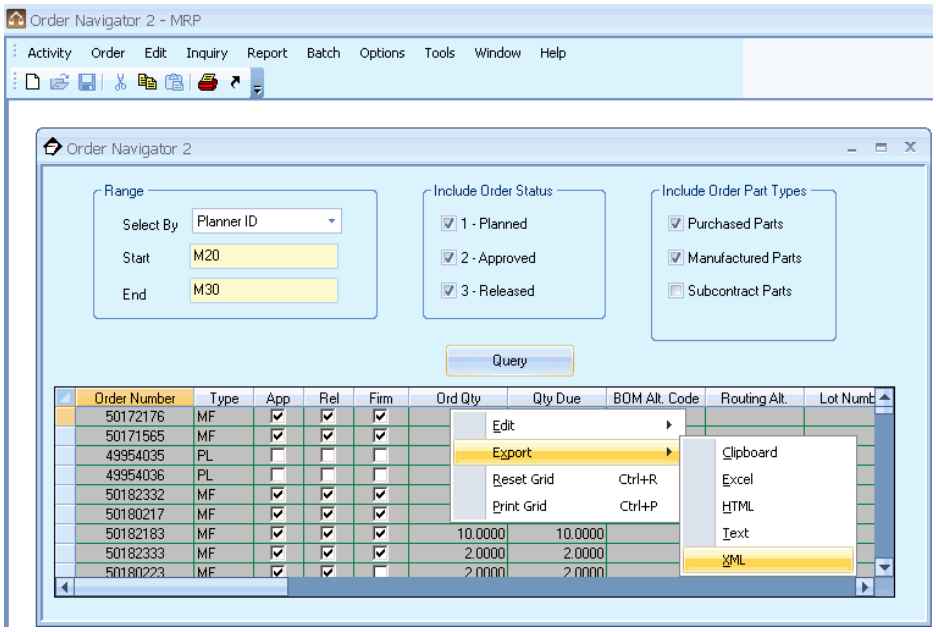
Before the level load tool can be used, the latest data must be exported from Exact MAX as an XML file. At this time, there is also a precautionary step that must be taken to ensure all relevant parts are being captured by the correct Planner ID. There is a known issue where some shop orders have nothing in the Planner ID field. Any such order will not appear in the plan if left unchanged.

Planner ID Check

1. Open Exact MAX and log in
2. Materials > MRP > Activity > Order Navigator > Select "Planner ID" from the drop down menu
3. Leave the Start and End fields **blank** and press Ente" or click the Query button
4. Now, scroll to the right and look under "Planner ID." If the field is blank, look at the part ID. If this part ID ought to be considered when planning the schedule, make a note of the order number for the next step. Do this for all parts without a Planner ID.
5. Close the MRP module and return to the Exact MAX main screen.
6. Production > Shop Floor Execution > Activity > Shop Order
7. Type into the "Ord Num" field one of the order numbers you wrote down then press Enter
8. When the record comes up, look for the Planner ID field and enter the correct Planner ID there
9. **Save** the changes and search for the next order, if any.

Exporting the data from Exact MAX:

1. Open Exact MAX and log in
2. Materials > MRP module > Activity > Order Navigator
3. Select "Planner ID" from the "Select by" drop down list
4. Start-End: M20-M30
5. Press Enter or click the Query button
6. Right-click anywhere in the data field > Export > XML
7. Save the XML file to **C:\MRP Data** (you may need to create this folder)



Step-by-step instructions (Abbreviated)

1. Update the data

2. Open the tool and verify that the values in the **Rules** and **Exclusion** sheets are up-to-date.

3. Go to the **Analysis** sheet and click 

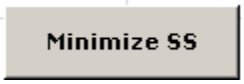
A dialog box will now come up. Enter in a start date, choose the "3 months" option, and click "OK". (While it is possible to manually enter an end date or to select the other available options, 3 months is recommended as a good range for mathematical reasons.)

4. With the range selected, click "OK" and then click 

The **Populate Qty Field** button will:

- Refresh the data in the workbook by referring to the XML file exported into C:\MRP Data
- Insert the ship and braze quantities into the sheet for every part

5. Enter in all delinquent quantities and the target number of days to complete. Now, click 

6. If you wish to minimize the safety stock value by increasing the level load number, click 

Otherwise, skip this step.

7. Click on row 7. On the Ribbon, go to View > Freeze Panes > Freeze Panes

8. With the pane frozen, scroll through all the parts and review the level load and safety stock values. If you wish to change the level load number, enter into the level load cell the value you want. Once *all* cells have been changed, click the **Recalculate SS** button. This button will calculate the safety stock required using the level load values you chose. **Do not** use the **Initialize SS** or **Minimize SS** buttons once you start making these manual changes as they will undo your work by recalculating the LL/SS values. If the issue cannot be resolved using the Recalculate SS button, consider some possible troubleshooting methods.

9. Go to the **Summary** sheet and click 

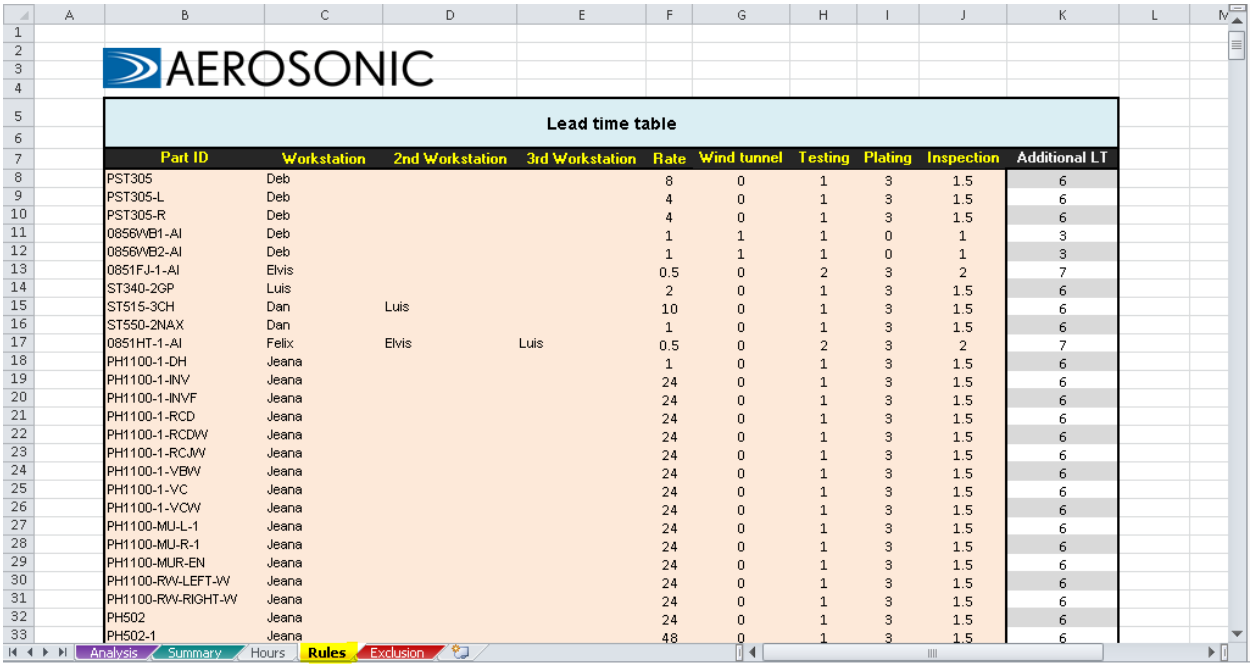
This will initiate a routine that will sum the weekly quantities due to be built for every part based on the information available on the Analysis sheet. Consider filtering the Operator column by looking at one individual's schedule at a time to check the feasibility.

Step-by-step instructions (Expanded)

**Note: This section assumes the latest XML data file has already been exported to C:\MRP Data.*

The following visual guide will illustrate the intended use of the level load tool. It follows closely the flowchart in the Overview section. An even more in-depth explanation for select topics will be at the end of this document.

1. As a first step, it is important to ensure that the data in the "Lead time table" on the **Rules** sheet is up-to-date. This table is referred to in other places in the workbook that rely on the data in this table being accurate. It associates a part ID with: a workstation, a rate, and the amount of time a given part would spend in the wind tunnel, testing, out for plating, or for inspection. The values in the "Additional LT" column dictate how much time there should be between when a part is finished brazing until it is completely ready to ship.



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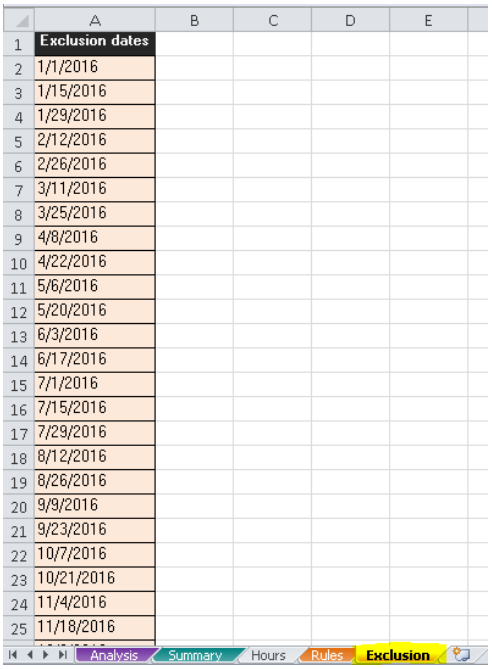
Lead time table

Part ID	Workstation	2nd Workstation	3rd Workstation	Rate	Wind tunnel	Testing	Plating	Inspection	Additional LT
PST305	Deb			8	0	1	3	1.5	6
PST305-L	Deb			4	0	1	3	1.5	6
PST305-R	Deb			4	0	1	3	1.5	6
0856WB1-AI	Deb			1	1	1	0	1	3
0856WB2-AI	Deb			1	1	1	0	1	3
0851FJ-1-AI	Elvis			0.5	0	2	3	2	7
ST340-2GP	Luis			2	0	1	3	1.5	6
ST515-3CH	Dan	Luis		10	0	1	3	1.5	6
ST550-2NAX	Dan			1	0	1	3	1.5	6
0851HT-1-AI	Felix	Elvis	Luis	0.5	0	2	3	2	7
PH1100-1-DH	Jeana			1	0	1	3	1.5	6
PH1100-1-INV	Jeana			24	0	1	3	1.5	6
PH1100-1-INVF	Jeana			24	0	1	3	1.5	6
PH1100-1-RCD	Jeana			24	0	1	3	1.5	6
PH1100-1-RCDW	Jeana			24	0	1	3	1.5	6
PH1100-1-RCJW	Jeana			24	0	1	3	1.5	6
PH1100-1-VBW	Jeana			24	0	1	3	1.5	6
PH1100-1-VC	Jeana			24	0	1	3	1.5	6
PH1100-1-VCW	Jeana			24	0	1	3	1.5	6
PH1100-MU-L-1	Jeana			24	0	1	3	1.5	6
PH1100-MU-R-1	Jeana			24	0	1	3	1.5	6
PH1100-MUR-EN	Jeana			24	0	1	3	1.5	6
PH1100-RW-LEFT-W	Jeana			24	0	1	3	1.5	6
PH1100-RW-RIGHT-W	Jeana			24	0	1	3	1.5	6
PH502	Jeana			24	0	1	3	1.5	6
PH502-1	Jeana			48	0	1	3	1.5	6

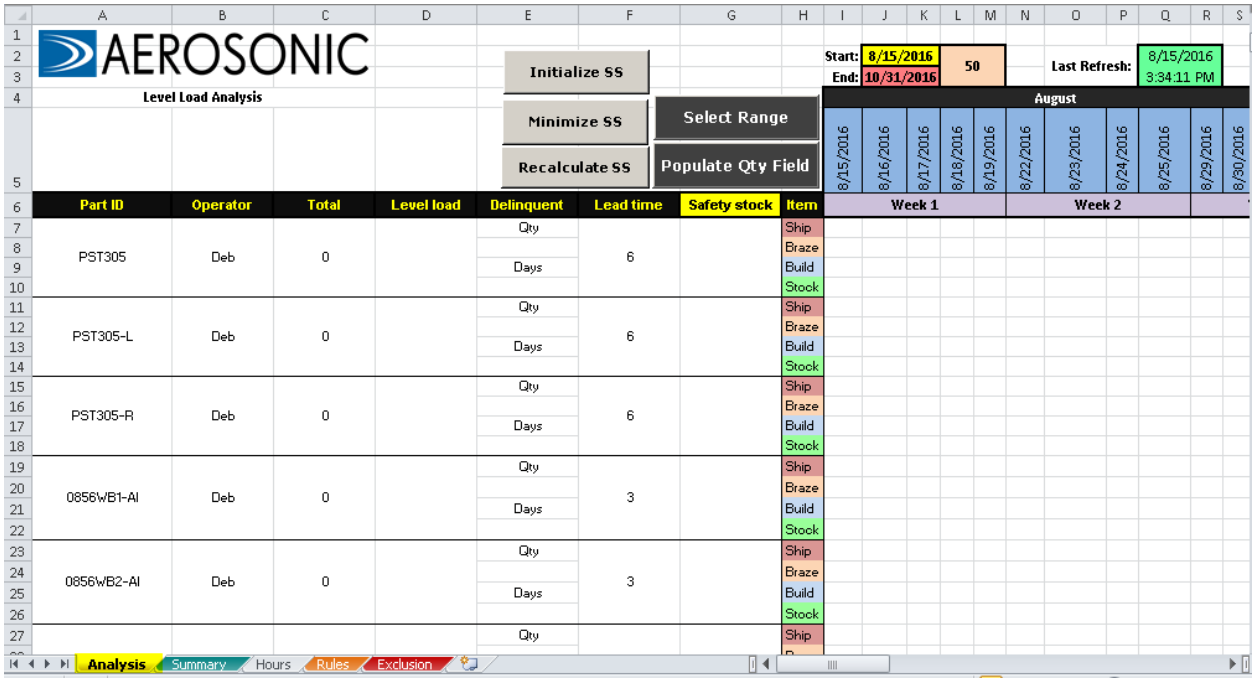
Analysis | Summary | Hours | **Rules** | Exclusion

2. The dates on the **Exclusion** sheet are all non-working days at Aerosonic that are not weekends. So these dates should include every non-working Friday and holidays. It is important that all non-working dates are included on this list; otherwise, it will appear on the level load schedule that more time is available than there is.



Exclusion dates
1/1/2016
1/15/2016
1/29/2016
2/12/2016
2/26/2016
3/11/2016
3/25/2016
4/8/2016
4/22/2016
5/6/2016
5/20/2016
6/3/2016
6/17/2016
7/1/2016
7/15/2016
7/29/2016
8/12/2016
8/26/2016
9/9/2016
9/23/2016
10/7/2016
10/21/2016
11/4/2016
11/18/2016

Analysis | Summary | Hours | Rules | **Exclusion**



3. With the Rules and Exclusion sheets updated, navigate to the "Analysis" sheet. Before moving to the next step, we will break down each section of this sheet.

Part ID	Operator	Total	Level load	Delinquent	Lead time	Safety stock	Item

The values in the **Part ID**, **Operator**, and **Lead time** columns all come from the Rules sheet. The Operator and Lead time values are retrieved formulaically using Excel's VLOOKUP function. The function uses the Part ID as the look-up value, refers to the table on the Rules sheet, and returns the primary Operator name and Lead time values to the appropriate cell.

The **Total** column is the sum of all the quantities to be shipped for a given part within the specified date range. This is done using Excel's built-in SUM function.

The **Level Load** value is initially calculated but can be edited by the user if the computed value is too low or too high. This value represents a constant number of units that must be built from one day to the next in order to satisfy all customer orders in time. The discussion on how this value is calculated begins here.

The **Delinquent** column requires user input, if applicable. If there are any delinquencies *before* the start of the cycle, there is a field to enter the number of delinquent parts ("Qty") and the number of days from the start of the cycle that they ought to be completed ("Days").

The **Safety stock** column is calculated with the level load. This value cannot be directly changed by the user. This value represents the number of units that must be available on-hand before the start of the cycle in order to cover peak customer demand.

The **Item** column repeats the same set of row names for each part: Ship, Braze, Build, Stock.

- The **Ship** row holds the quantities due in the cell corresponding to the date that matches the current date defined in the work order.
- The **Braze** row places the same quantity back from the current date by an amount equal to the lead time value defined on the Rules table.
- The **Build** row inserts the level load number into each cell in the row until the amount held in stock exceeds the remaining number of units needing to be built by the end of the cycle; when that occurs, a '0' is inserted into the cell instead of the level load number.
- The value in any given cell in the **Stock** row is calculated as:

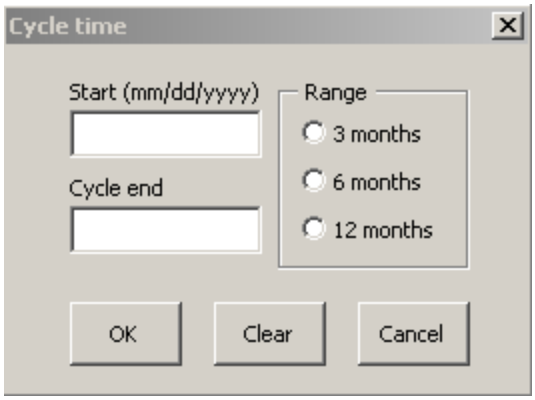
Ship
Braze
Build
Stock

$$Stock_t = Stock_{t-1} + Build_{t-1} - Braze_{t-1}$$

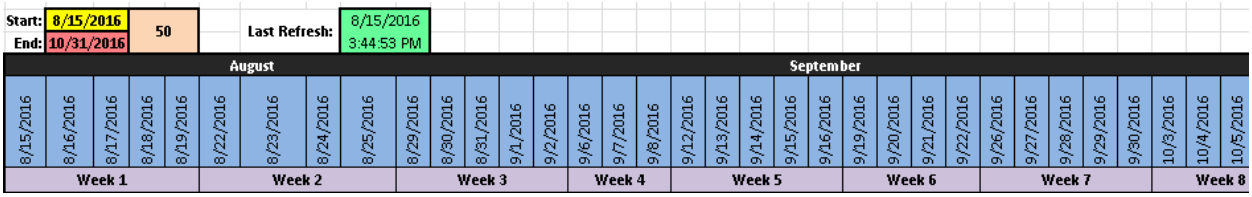
**where subscript 't' indicates "today"; 't-1' is "yesterday"*

4. To get started, click **Select Range**

This will bring up the Cycle time dialog box:



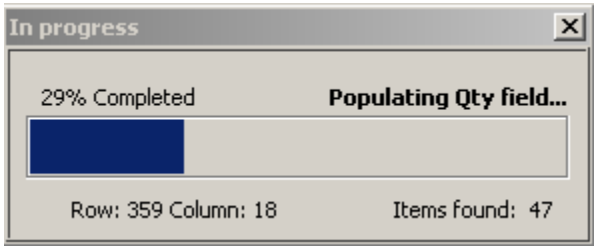
On the right side of the form, there are three radio buttons available to generate an end date that is 3 months, 6 months, or 12 months from the start date. However, any value can be manually input into the end date field. Once the OK button is clicked, the sheet is reformatted – clearing all values, borders, and shading from the table. The dates are inserted and broken into months and weeks.



Once the date range is selected, all dates excluding weekends and the dates specified on the Exclusion sheet will be generated as shown. Above the date range, there is a "start" and "end" box. The values in that box are inserted after using the Select Range button; the value next to it is the number of days in the cycle. The "Last Refresh" box is stamped whenever a new range is specified and the quantity field is re-populated. Changing these values by interacting with the cells they are in directly will not do anything.

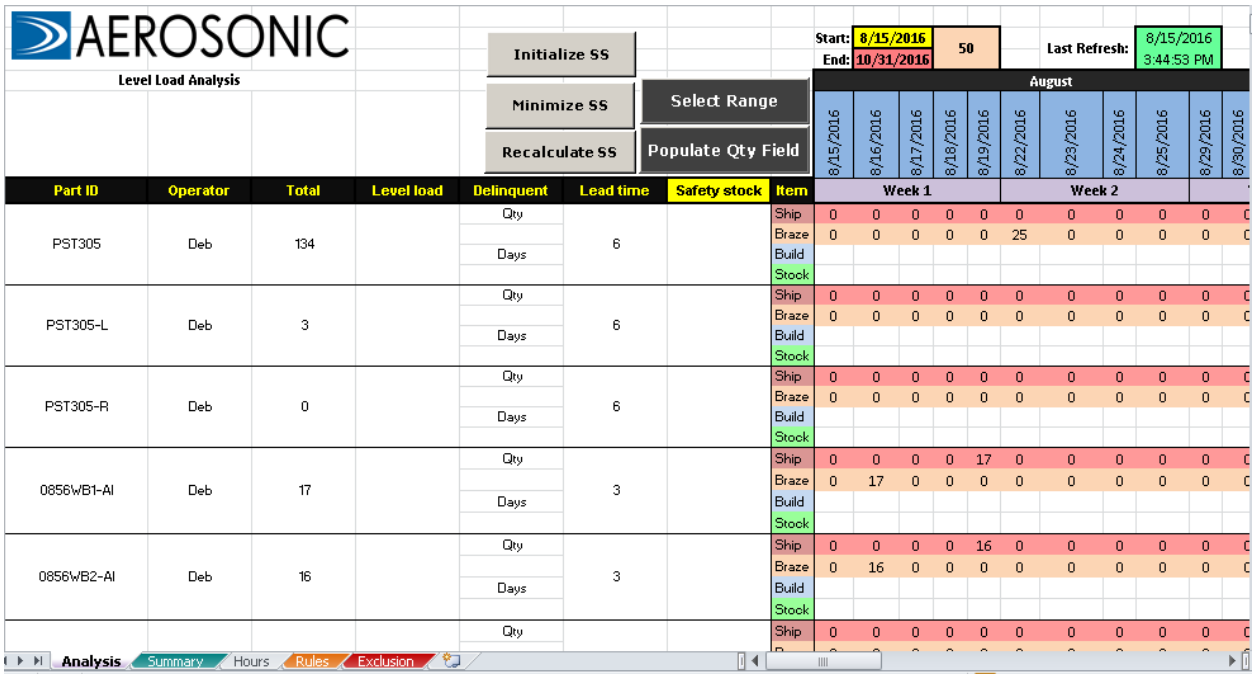
5. With the date range specified, click **Populate Qty Field**

You should now see the following loading bar pop up.



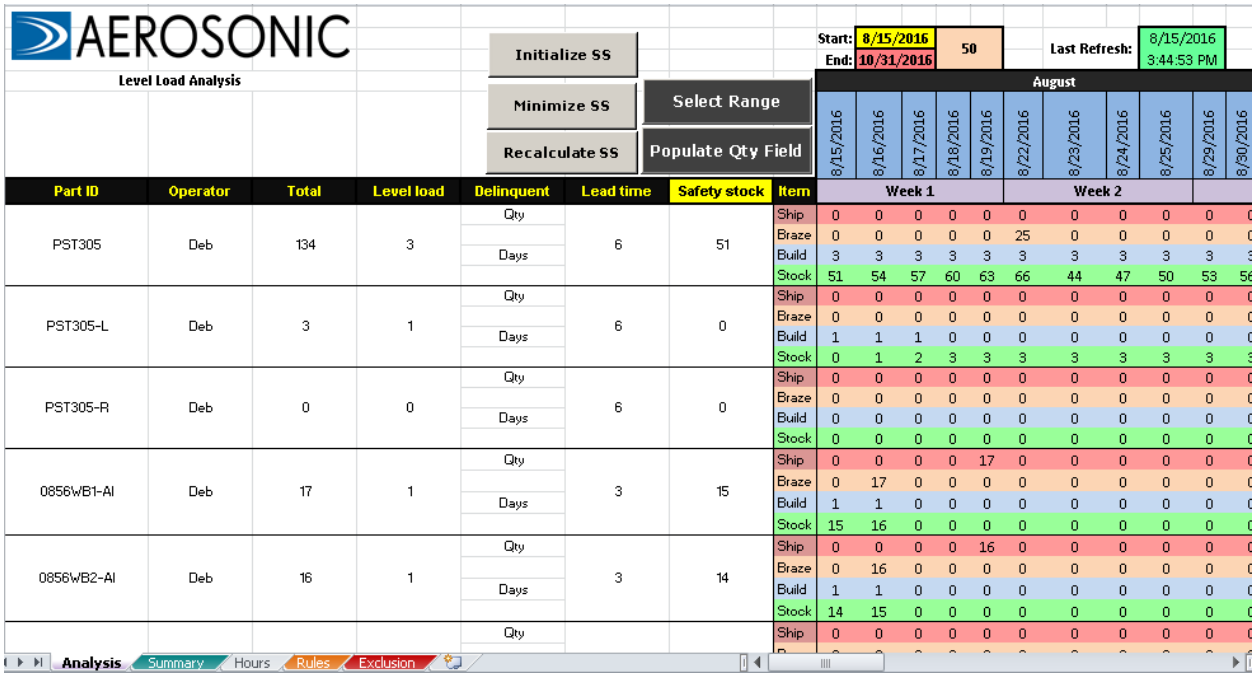
This routine cycles through every Ship and Braze row on the Analysis sheet for each column; the columns contain working days and the rows contain part IDs. Each part ID and date from the Analysis sheet is evaluated against every date-part pair on the Pivot sheet until a match is found, at which time, the Quantity Due value from the Pivot sheet is retrieved and written into the corresponding cell on the Analysis sheet.

The sheet should look like this. The **Total** column is now able to calculate a value.



6. With the quantities inserted into the sheet, we can determine what the safety stock and level load values should be in order to meet customer demand.

To begin the analysis, click **Initialize SS**



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Level Load Analysis

Initialize SS | Minimize SS | Recalculate SS | Select Range | Populate Qty Field

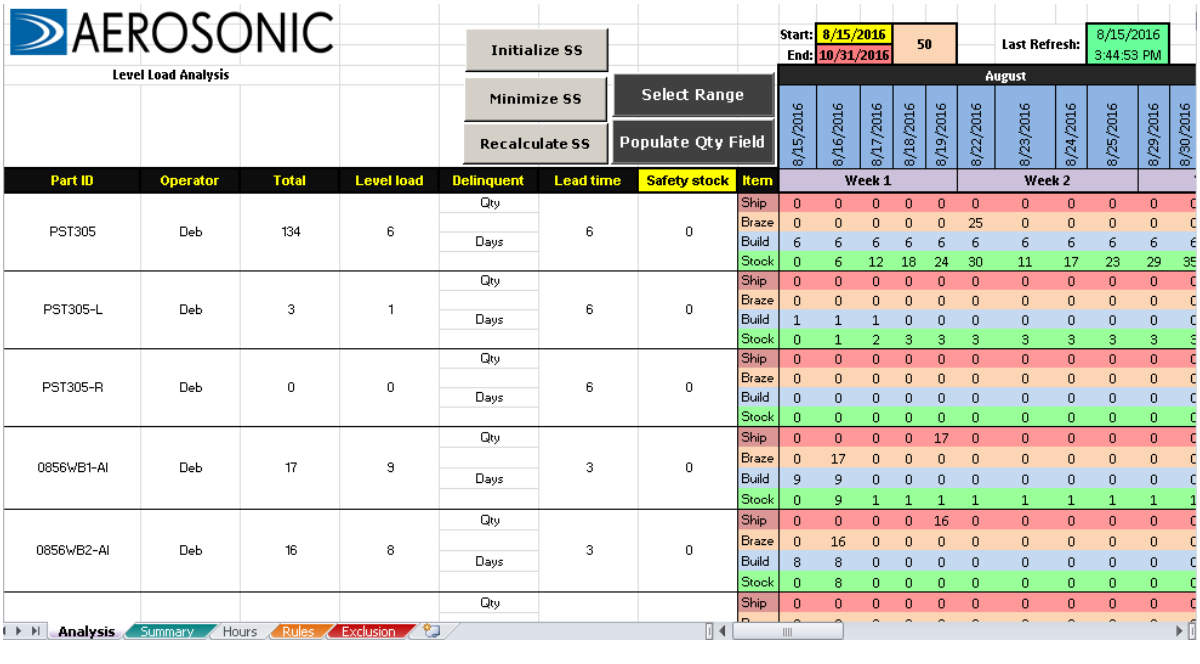
Start: 8/15/2016 End: 10/31/2016 | 50 | Last Refresh: 8/15/2016 3:44:53 PM

Part ID	Operator	Total	Level load	Delinquent	Lead time	Safety stock	Item	August 8/15/2016	8/16/2016	8/17/2016	8/18/2016	8/19/2016	8/22/2016	8/23/2016	8/24/2016	8/25/2016	8/29/2016	8/30/2016
								Week 1					Week 2					
PST305	Deb	134	3	Qty	6	51	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	25	0	0	0	0	0
				Days			Build	3	3	3	3	3	3	3	3	3	3	3
							Stock	51	54	57	60	63	66	44	47	50	53	56
PST305-L	Deb	3	1	Qty	6	0	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	0	0	0	0	0	0
				Days			Build	1	1	1	0	0	0	0	0	0	0	0
							Stock	0	1	2	3	3	3	3	3	3	3	3
PST305-R	Deb	0	0	Qty	6	0	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	0	0	0	0	0	0
				Days			Build	0	0	0	0	0	0	0	0	0	0	0
							Stock	0	0	0	0	0	0	0	0	0	0	0
0856WB1-AI	Deb	17	1	Qty	3	15	Ship	0	0	0	0	17	0	0	0	0	0	0
							Braze	0	17	0	0	0	0	0	0	0	0	0
				Days			Build	1	1	0	0	0	0	0	0	0	0	0
							Stock	15	16	0	0	0	0	0	0	0	0	0
0856WB2-AI	Deb	16	1	Qty	3	14	Ship	0	0	0	0	16	0	0	0	0	0	0
							Braze	0	16	0	0	0	0	0	0	0	0	0
				Days			Build	1	1	0	0	0	0	0	0	0	0	0
							Stock	14	15	0	0	0	0	0	0	0	0	0
				Qty			Ship	0	0	0	0	0	0	0	0	0	0	0

Analysis | Summary | Hours | Rules | Exclusion

Taking the PST305 as an example, we can see that there is a level load of **3** and a safety stock of **51**. We know the operator can build more than 3 of these parts per day but we may not have 51 units on hand before starting this cycle. In fact, there are many cases where the safety stock will be computed as a value much higher than is realistic.

7. To resolve this issue, click **Minimize SS**



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Level Load Analysis

Initialize SS | Minimize SS | Recalculate SS | Select Range | Populate Qty Field

Start: 8/15/2016 End: 10/31/2016 | 50 | Last Refresh: 8/15/2016 3:44:53 PM

Part ID	Operator	Total	Level load	Delinquent	Lead time	Safety stock	Item	August 8/15/2016	8/16/2016	8/17/2016	8/18/2016	8/19/2016	8/22/2016	8/23/2016	8/24/2016	8/25/2016	8/29/2016	8/30/2016
								Week 1					Week 2					
PST305	Deb	134	6	Qty	6	0	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	25	0	0	0	0	0
				Days			Build	6	6	6	6	6	6	6	6	6	6	6
							Stock	0	6	12	18	24	30	11	17	23	29	35
PST305-L	Deb	3	1	Qty	6	0	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	0	0	0	0	0	0
				Days			Build	1	1	1	0	0	0	0	0	0	0	0
							Stock	0	1	2	3	3	3	3	3	3	3	3
PST305-R	Deb	0	0	Qty	6	0	Ship	0	0	0	0	0	0	0	0	0	0	0
							Braze	0	0	0	0	0	0	0	0	0	0	0
				Days			Build	0	0	0	0	0	0	0	0	0	0	0
							Stock	0	0	0	0	0	0	0	0	0	0	0
0856WB1-AI	Deb	17	9	Qty	3	0	Ship	0	0	0	0	17	0	0	0	0	0	0
							Braze	0	17	0	0	0	0	0	0	0	0	0
				Days			Build	9	9	0	0	0	0	0	0	0	0	0
							Stock	0	9	1	1	1	1	1	1	1	1	1
0856WB2-AI	Deb	16	8	Qty	3	0	Ship	0	0	0	0	16	0	0	0	0	0	0
							Braze	0	16	0	0	0	0	0	0	0	0	0
				Days			Build	8	8	0	0	0	0	0	0	0	0	0
							Stock	0	8	0	0	0	0	0	0	0	0	0
				Qty			Ship	0	0	0	0	0	0	0	0	0	0	0

Analysis | Summary | Hours | Rules | Exclusion

The **Minimize SS** button determines the smallest level load number possible in order to make it so a **minimal amount** of safety stock need be available before the cycle start. In the case of the PST305, the safety stock was driven to 0 as the level load was to 6. We know that the operator can build 6 per day so this is a very convenient result.

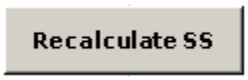
The **Recalculate SS** button is the last button available to the user. It gives the user the opportunity to define themselves what the level load value ought to be. Here are two important rules to bear in mind:

1. After using the Minimize SS button, *lowering* the level load value and recalculating SS will mean that your safety stock number is going to go **up**.
2. After using the Minimize SS button, *increasing* the level load value and recalculating SS will keep the SS value minimized while decreasing the number of days an operator needs to build that part.

Therefore, the recalculate SS button works *best* when: the safety stock is 0 and the calculated level load value is less than what the operator is capable of. The example below illustrates this:

83	PH1100-MU-L-1	Jeana	23	1	Qty	6	0	Ship	0	0	0	0
84								Braze	0	0	0	0
85					Days			Build	1	1	1	1
86								Stock	0	1	2	3

Here, the Minimize SS button has already been used. The safety stock is **0** and the level load is just **1**. Let's say we know the operator can build 4 units per day. Type '4' into the level load cell.

Now, click 

83	PH1100-MU-L-1	Jeana	23	4	Qty	6	0	Ship	0	0	0	0
84								Braze	0	0	0	0
85					Days			Build	4	4	4	4
86								Stock	0	4	8	12

This effectively reduces the number of days the operator will need to build the total quantity due from 23 days to just 6. Decreasing the number of days she needs to dedicate to building this particular part doesn't impact our ability to ship on time – she was going to do that anyway building one per day. However, if her workload was thin, there is no penalty for increasing the level load here and having her build the order sooner; filling up time in the day that otherwise might have gone wasted.

The distance in time between when a part is to ship and when it needs to be finished with brazing is controlled by the Additional LT value on the Rules sheet (**Fig A**).

Figure A

Figure B

Ship	0	0	0	0	0	0	25
Braze	25	0	0	0	0	0	0
Build	3	3	3	3	3	3	3
Stock	60	38	41	44	47	50	53

This is important to know because if a ship date occurs within a number of days equal to the lead time from the cycle start date – the tool looks at that and says there is not enough time to finish brazing those orders (**Fig B).** Therefore, the quantity needed within that window of time must be held in safety stock.

8. The Summary sheet, as its name implies, summarizes the quantities needing to be completed for every part on a weekly basis.

Update the table values by clicking 

Part ID	Operator	SS	Week 1 8/15/2016	Week 2 8/22/2016	Week 3 8/29/2016	Week 4 9/6/2016	Total

The Operator column uses VLOOKUP to insert an operator name from the Rules sheet based on the value in the corresponding Part ID cell. The SS is taken from the Analysis sheet and if the value is greater than '0', the cell is shaded in red. Taking Week 1 as an example, the values in this column represent the sum of the build quantities that occur in that week for a given part. The SS and weekly quantities are inserted using a macro.

Part ID	Operator	SS	Week 1 8/15/2016	Week 2 8/22/2016	Week 3 8/29/2016	Week 4 9/6/2016	Total
PST305	Deb	0	30	24	30	18	102
PST305-L	Deb	0	3	0	0	0	3
PST305-R	Deb	0	0	0	0	0	0
0856WB1-AI	Deb	0	18	0	0	0	18
0856WB2-AI	Deb	0	16	0	0	0	16
0851FJ-1-AI	Elvis	0	5	4	1	0	10
ST340-2GP	Luis	0	0	0	0	0	0
ST515-3CH	Dan	17	20	12	0	0	32
ST550-2NAX	Dan	0	10	8	8	0	26
0851HT-1-AI	Felix	53	5	4	3	0	12
PH1100-1-DH	Jeana	0	0	0	0	0	0
PH1100-1-INV	Jeana	9	5	4	2	0	11
PH1100-1-INVF	Jeana	0	15	12	0	0	27
PH1100-1-RCD	Jeana	0	6	0	0	0	6
PH1100-1-RCDW	Jeana	9	5	4	5	3	17
PH1100-1-RCJW	Jeana	0	0	0	0	0	0
PH1100-1-VBW	Jeana	2	10	8	10	0	28
PH1100-1-VC	Jeana	0	5	4	5	1	15
PH1100-1-VCW	Jeana	4	5	4	2	0	11
PH1100-MU-L-1	Jeana	0	5	4	5	3	17
PH1100-MU-R-1	Jeana	0	5	4	4	0	13
PH1100-MUR-EN	Jeana	0	0	0	0	0	0
PH1100-RW-LEFT-W	Jeana	0	5	3	0	0	8
PH1100-RW-RIGHT-W	Jeana	3	10	8	10	6	34
PH502	Jeana	0	35	28	35	21	119
PH502-1	Jeana	0	25	20	25	15	85
PH502-10	Jeana	0	5	4	5	1	15

Analysis | Summary | Hours | Rules | Exclusion

Troubleshooting LL/SS Values

Unfortunately, not all cases are convenient and can be handled by the formulas and algorithms offered by this tool. Below, we are looking at the 0851HT-1-Al as an example. The Minimize SS button has been utilized and it was determined that the smallest safety stock value is 9 for a level load of 23.

43	0851HT-1-Al	Felix	65	23	Qty	7	9	Ship	0	0	0	0	10	0	0	0	45	0	0
44								Braze	10	45	0	0	0	0	0	0	0	5	0
45					Days			Build	23	23	23	0	0	0	0	0	0	0	0
46								Stock	9	22	0	23	23	23	23	23	23	23	18

We know this operator can build maybe 1 of these parts per day, so we change the level load number to 1 and use the Recalculate SS button. This gives the following result:

43	0851HT-1-Al	Felix	65	1	Qty	7	53	Ship	0	0	0	0	10	0	0	0	45	0	0
44								Braze	10	45	0	0	0	0	0	0	0	5	0
45					Days			Build	1	1	1	1	1	1	1	1	1	1	1
46								Stock	53	44	0	1	2	3	4	5	6	7	3

What this is saying is that we may build 1 unit per day because that is compatible with reality, but we will need to have 53 units on hand to cover all shipments. What else can be done here? There are a few options if the safety stock is not entirely there.

1. Let's assume we do have *some* amount on hand, say 40 units. We can manually change the values in the Ship and Braze rows by subtracting 40 from the existing values like so:

Ship	0	0	0	0	10	0	0	0	45
Braze	10	45	0	0	0	0	0	0	0
Build	1	1	1	1	1	1	1	1	1
Stock	53	44	0	1	2	3	4	5	6

Ship	0	0	0	0	0	0	0	0	15
Braze	0	15	0	0	0	0	0	0	0
Build	1	1	1	1	1	1	1	1	1
Stock	53	44	0	1	2	3	4	5	6

   We wanted to remove 40 so we eliminated the 10 from the braze and ship rows by manually replacing it with a '0'. We still want to subtract 30, so we take 30 from the quantity of 45 in both the braze and ship rows. With the desired changes made, click **Recalculate SS.**

43	0851HT-1-Al	Felix	25	1	Qty	7	13	Ship	0	0	0	0	0	0	0	0	15
44								Braze	0	15	0	0	0	0	0	0	0
45					Days			Build	1	1	1	1	1	1	1	1	1
46								Stock	13	14	0	1	2	3	4	5	6

   After accounting for the 40 we had on hand and maintaining a manual level load of '1', we still need to have a safety stock of 13.

2. We should also take into consideration that multiple operators can build this part. By default, the operator field retrieves the value from the Rules table indicating who the primary operator is. This by no means is to say that, in this case, Felix is the only operator who should work on this part. Let's say we have 4 operators who all work at the same rate of 1 per day. We are effectively saying that our level load then can be '4' (1 part per day per operator). Enter '4' into the level load field and recalculate. This gives us:

43	0851HT-1-AI	Felix	25	4	Qty	7	7	Ship	0	0	0	0	0	0	0	0	15
44								Braze	0	15	0	0	0	0	0	0	0
45					Days			Build	4	4	4	4	4	0	0	0	0
46								Stock	7	11	0	4	8	12	12	12	12

At this point, we have really done all we can to manipulate our parameters inside the tool so as to minimize the safety stock and keep the level load reasonable. The safety stock of '7' can be said to be the true amount required to have on hand to be on time.

3. Our problem here is that we need 15 units on the 2nd day from the cycle start date to be finished with brazing. The tool says our only option is to drive up the level load number to eliminate the safety stock. However, a solution outside the scope of the tool is to change the current date for the work order in Exact MAX. By pushing back the due date, we are, of course, allowing for more time to build up the order.

Appendix A: Mathematics

This section covers the math used to calculate the level load and safety stock values.

I. Initialize SS Calculation

First, we will look at how the **Initialize SS** button works. Immediately below is an example assuming a lead time of 1 day, i.e., after brazing the part has one additional day of processing before being ready to ship.

Total	16
Days	8
LL	2
RoundUp_LL	2
SS	7

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	2	2	2	2	2	2	2	0
X	0	2	-1	2	-6	2	4	5
Have	0	2	0	2	0	2	4	5
Safety Stock	0	0	-1	0	-6	0	0	0

The **Total** is the sum of the quantities in the braze row:

$$\mathbf{16 = 0 + 5 + 0 + 10 + 0 + 0 + 1 + 0}$$

The **Days** represent the number of days in the cycle. In this case, it's **8**.

The **LL** (Level Load) value is calculated as:

$$\boldsymbol{LL = \frac{Total}{Days} = \frac{16}{8} = 2}$$

To discuss how the **SS** (Safety Stock) is calculated we must understand the table above in more detail.

The **Build** row in the table above works like this: If the remaining quantity to be brazed exceeds the amount we **Have**, then we need to build in increments equal to the level load value; if not, then as indicated in the last column, insert a '0'.

The **X, Have,** and **Safety Stock** rows are calculated differently for the 1st column than for every subsequent column thereafter.

For the 1st column,

$$\boldsymbol{X = Have = Safety\ Stock = 0}$$

For the 2nd column until the last (where ***j*** is a subscript representing the current column),

$$X_j = (Build)_{j-1} + (Have)_{j-1} - (Braze)_{j-1}$$

Example 1: $X_2 = (Build)_1 + (Have)_1 - (Braze)_1 = 2 + 0 - 0 = 2$
Example 2: $X_3 = (Build)_2 + (Have)_2 - (Braze)_2 = 2 + 2 - 5 = -1$

The **Have** value is determined with the following logical statement:

$$\begin{cases} X_j > 0 \; then \; (Have)_j = X_j \\ X_j \leq 0 \; then \; (Have)_j = 0 \end{cases}$$

The **Safety Stock** value is determined with the converse logical statement:

$$\begin{cases} X_j < 0 \; then \; (Safety \; Stock)_j = X_j \\ X_j \geq 0 \; then \; (Safety \; Stock)_j = 0 \end{cases}$$

In words, the X value is just a placeholder. Simply put, if its value is above zero then we carry this amount as stock for the next day – it's how much we **Have**. If its value is less than zero, that's how much we *should* have had in stock up to this point – since we don't, we assign this amount to the safety stock needed for that day and say we **Have** 0 available for the next day.

The final SS value takes the absolute value of the sum of all the safety stock values.

$$SS = \left| \sum_{n=1}^{8} (Safety \; Stock)_n \right| = |0 + 0 - 1 + 0 - 6 + 0 + 0 + 0| = |-7| = \mathbf{7}$$

The SS value of **7** tells us that we must have 7 units on hand before the start of the cycle in order to cover all the shipments if a level load of 2 is used. Inserting 7 as our initial **Have** value gives:

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	2	2	2	2	2	0	0	0
X	0	9	6	8	0	2	2	1
Have	7	9	6	8	0	2	2	1
Safety Stock	0	0	0	0	0	0	0	0

II. Minimize SS Calculation

The Minimize SS button works similarly to the Initiate SS button except that we start with the level load value as being unknown. Instead, we initialize an *estimated* level load value at 1 and increment by 1 until the safety stock is 0. In effect, we are discovering the **smallest** level load value for which we would need **either no or a minimal amount** of safety stock. The algorithm used to determine what the level load value should be is summarized below in pseudocode:

```
est_LL = 1

Do While (SS does not equal 0)

      Calculate SS

      If (SS equals 0) Then
            Exit Loop
      End if

      est_LL = est_LL + 1

Loop
```

Using the same data set for the ship and braze quantities as was used in the Initialize SS discussion, the resulting table of values for the first iteration of the loop is made available below.

Total	16
Days	8
Est. LL	1
Min LL	1
SS	-11

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	1	1	1	1	0	1	1	0
X	0	1	-3	1	-8	0	1	1
Have	0	1	0	1	0	0	1	1
Safety Stock	0	0	-3	0	-8	0	0	0

The program initializes the level load at 1 and checks whether the safety stock is 0 before incrementing the level load again. Since the safety stock is 11, the condition to end the loop has not been satisifed and it will therefore perform another iteration. On the next page, let's see how these values change with each iteration. Bear in mind, the only variable being manipulated is the estimated level load:

Total	16
Days	8
Est. LL	2
Min LL	2
SS	-7

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	2	2	2	2	0	2	2	0
X	0	2	-1	2	-6	0	2	3
Have	0	2	0	2	0	0	2	3
Safety Stock	0	0	-1	0	-6	0	0	0

Total	16
Days	8
Est. LL	3
Min LL	3
SS	-3

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	3	3	3	3	0	3	3	0
X	0	3	1	4	-3	0	3	5
Have	0	3	1	4	0	0	3	5
Safety Stock	0	0	0	0	-3	0	0	0

Total	16
Days	8
Est. LL	4
Min LL	4
SS	0

Ship	0	0	5	0	10	0	0	1
Braze	0	5	0	10	0	0	1	0
Build	4	4	4	4	0	0	0	0
X	0	4	3	7	1	1	1	0
Have	0	4	3	7	1	1	1	0
Safety Stock	0	0	0	0	0	0	0	0

At this point, the loop ends because the condition that the safety stock be 0 has been satisifed. If we continued to increment the level load until it was 5, 6, 7, and so on… the safety stock would still be 0. So '4' is the ***smallest*** level load value for which we need not carry any safety stock. As a point of interest, compare the safety stock value we got in the table above for an estimated level load of '2' to the safety stock we found in Section I using the level load that was calculated as an average (it's the same).

Appendix B: Making changes by sheet

I. Analysis

- It is not advisable to try and make changes to the Analysis sheet *except* the occasional and necessary task of inserting new Part IDs to the bottom of the sheet; additional, blank rows have been formatted and made available on the bottom of the table for that purpose but new ones can be created manually so long as the formatting is identical. The only information that needs to be inserted is the Part ID – the other columns use VLOOKUP and macros to generate their values.

  The difficulty with adding rows and columns to the Analysis sheet is that many of the values are calculated using loops with Visual Basic that define a starting point using a specific row and a specific column. A common "For" loop in the program is structured like this:

```
startRow = 7
startCol = 9

for i = startRow to LastRow
      for j = startCol to LastColumn
            Cells(i + 2, j).Value = some_value
      Next j
i = i + 3
Next i
```

  In words, this says we are starting on row 7 (the ship row for the first part) and column 9 (the column corresponding to the first date in the cycle). We then assign some value to the cell that is 2 rows below the ship row (which is the build row) corresponding to the 1st date.

  The "Next j" line increments 'j' by 1 to point to the next column (date) on the next iteration. We continue to assign values to the same build row until the last column is reached. Then, we directly increment 'i' by '3' to the current value before the "Next i" line, again, increments 'i' by 1. So on the next iteration of the loop, the program is looking at the ship row of the 2nd part (i = 4) and will cycle through every column, assigning values to the build row for that part. The loop is executed until the last row is evaluated.

  The point being made here is that in order to create new rows and columns on the Analysis sheet, changes would need to be made to the starting indices for these loops. This is both time consuming and may cause faults elsewhere in the program. If new columns or rows need to be added, here some suggestions, in order of ease:

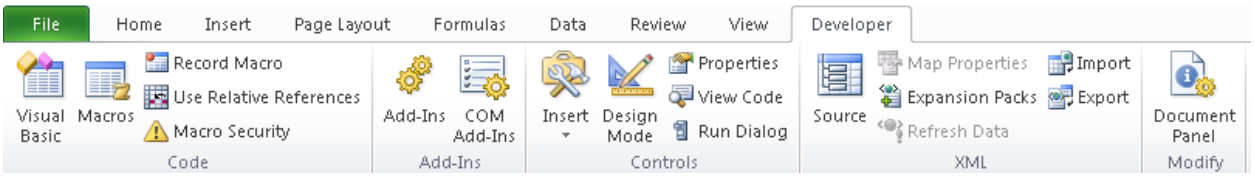
  - Repurpose the **Operator** or **Delinquent** columns. The Operator column is largely not needed on this sheet. Nothing would be affected by leaving it blank – do not, however, delete the column.
  - Create a new sheet with the rows and columns needed and simply pull information off the Analysis sheet. Creating new sheets will not affect how the tool works if those sheets are added at the end (after the Exclusion sheet).
  - To add columns to the Analysis sheet, insert them *after* the last date in the cycle has been generated with the Select Range button. This would need to be done every time a new range was generated unless a new macro was created to insert and format the additional columns.

If the alternative solutions presented in the bulleted list at the end of the last page will not suffice, here is how to change the indices.

If the Developer tab is not available on the Ribbon, do the following to make it visible:

File > Options > Customize Ribbon > Add the Developer tab to the list on the right > Click “OK”

With the Developer tab selected, click on the **Visual Basic** button on the far left.



If columns need to be added to the Analysis sheet, take note of the following before moving forward:

Module > Subroutine > Button [Sheet]

Module 12 > SS_Calculation > **Initiate SS** [Analysis]

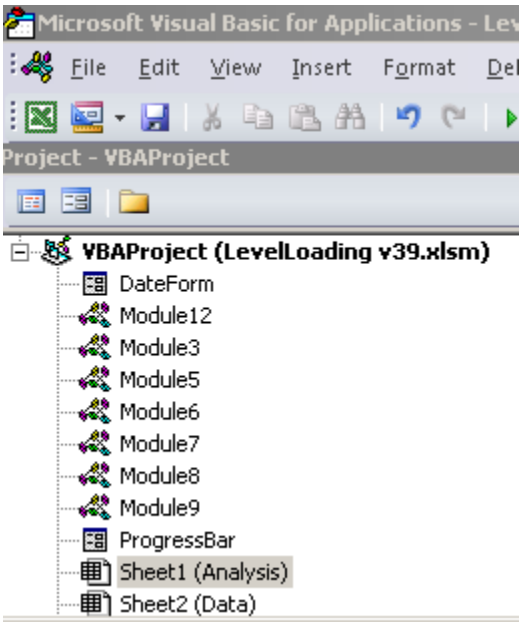
Module 6 > SS_Calculation2 () > **Recalculate SS** [Analysis]

Module 7 > Optimize_SS () > **Minimize SS** [Analysis]

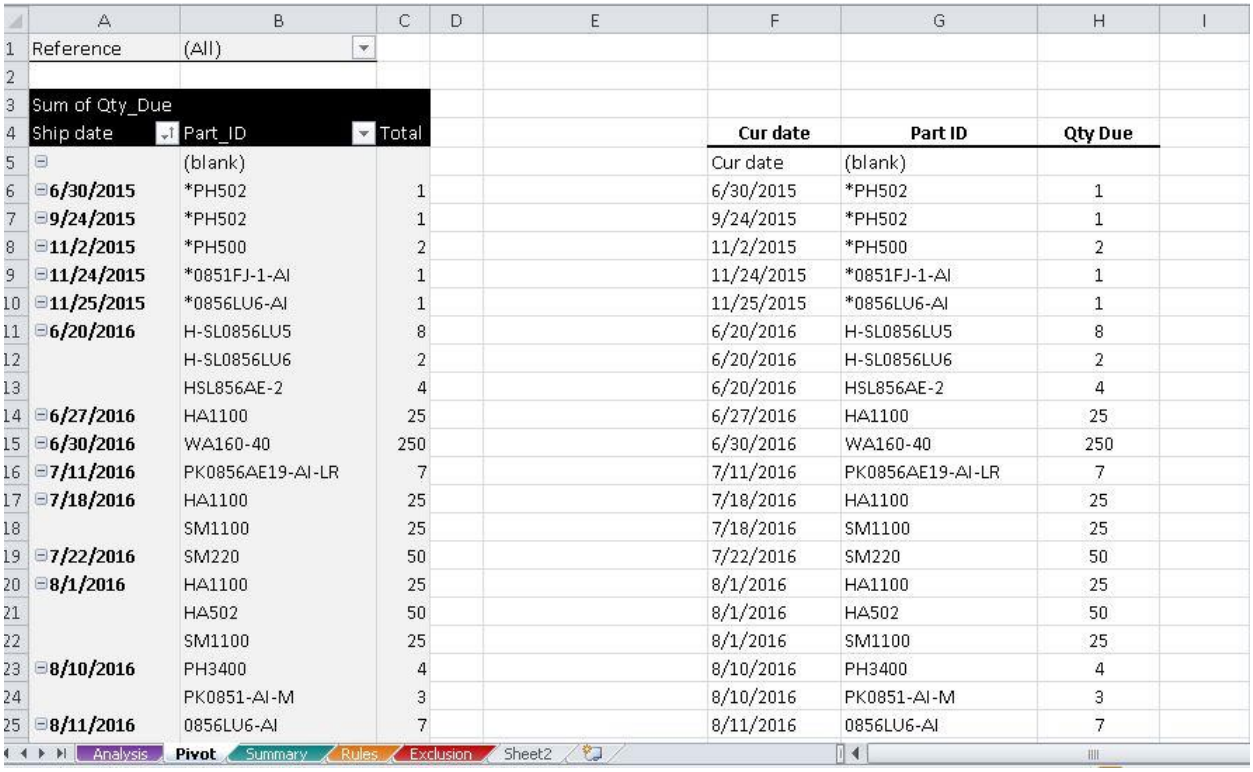
Module 3 > Delinquent ()
*Subroutine gets called by: SS_Calculation, SS_Calculation2, Optimize_SS

The **ProgressBar** and **DateForm** items can and will need to be changed. These are userforms. To view the code, right-click on either of those items and click “View Code”

After the Visual Basic button has been clicked, you should see screen on the right.



II. Pivot

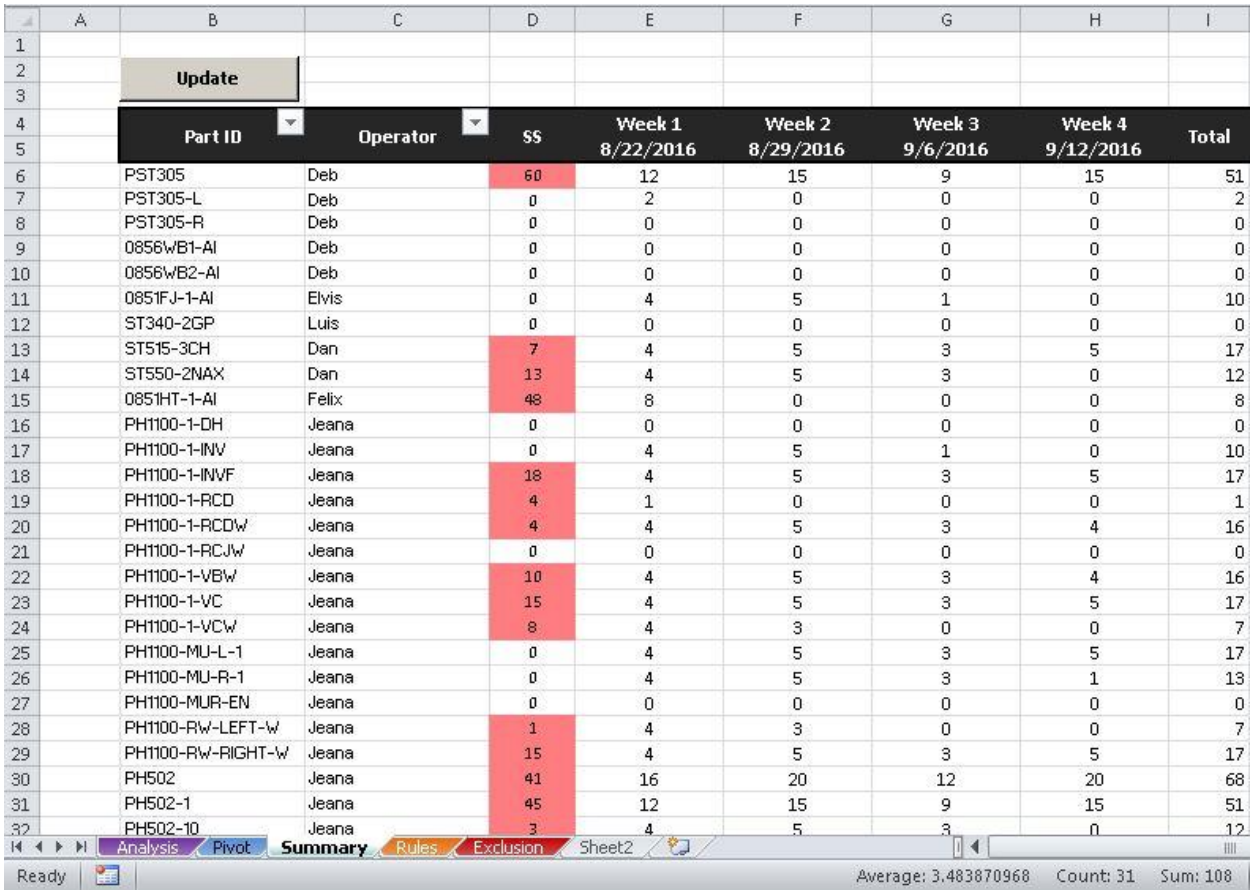


Reference	(All)							
Sum of Qty_Due								
Ship date	Part_ID	Total			Cur date	Part ID	Qty Due	
	(blank)				Cur date	(blank)		
6/30/2015	*PH502	1			6/30/2015	*PH502	1	
9/24/2015	*PH502	1			9/24/2015	*PH502	1	
11/2/2015	*PH500	2			11/2/2015	*PH500	2	
11/24/2015	*0851FJ-1-AI	1			11/24/2015	*0851FJ-1-AI	1	
11/25/2015	*0856LU6-AI	1			11/25/2015	*0856LU6-AI	1	
6/20/2016	H-SL0856LU5	8			6/20/2016	H-SL0856LU5	8	
	H-SL0856LU6	2			6/20/2016	H-SL0856LU6	2	
	HSL856AE-2	4			6/20/2016	HSL856AE-2	4	
6/27/2016	HA1100	25			6/27/2016	HA1100	25	
6/30/2016	WA160-40	250			6/30/2016	WA160-40	250	
7/11/2016	PK0856AE19-AI-LR	7			7/11/2016	PK0856AE19-AI-LR	7	
7/18/2016	HA1100	25			7/18/2016	HA1100	25	
	SM1100	25			7/18/2016	SM1100	25	
7/22/2016	SM220	50			7/22/2016	SM220	50	
8/1/2016	HA1100	25			8/1/2016	HA1100	25	
	HA502	50			8/1/2016	HA502	50	
	SM1100	25			8/1/2016	SM1100	25	
8/10/2016	PH3400	4			8/10/2016	PH3400	4	
	PK0851-AI-M	3			8/10/2016	PK0851-AI-M	3	
8/11/2016	0856LU6-AI	7			8/11/2016	0856LU6-AI	7	

Analysis | Pivot | Summary | Rules | Exclusion | Sheet2

The **Pivot** sheet is hidden by default as there has been no need for a user to access and manipulate its contents. If needed, additional columns can be added past the "H" column without affecting the rest of the workbook. To remove Part IDs with a "*" preceding the name, click on the Reference filter, check the box that says "Select Multiple Items", and then deselect all items starting with: "800…". "Blanks" and "Reworks" may also be deselected, if desired. *Note*: by checking the "Select Multiple Items" box, new items that populate in the filter will be deselected by default.

III. Summary



Update

Part ID	Operator	SS	Week 1 8/22/2016	Week 2 8/29/2016	Week 3 9/6/2016	Week 4 9/12/2016	Total
PST305	Deb	60	12	15	9	15	51
PST305-L	Deb	0	2	0	0	0	2
PST305-R	Deb	0	0	0	0	0	0
0856WB1-AI	Deb	0	0	0	0	0	0
0856WB2-AI	Deb	0	0	0	0	0	0
0851FJ-1-AI	Elvis	0	4	5	1	0	10
ST340-2GP	Luis	0	0	0	0	0	0
ST515-3CH	Dan	7	4	5	3	5	17
ST550-2NAX	Dan	13	4	5	3	0	12
0851HT-1-AI	Felix	48	8	0	0	0	8
PH1100-1-DH	Jeana	0	0	0	0	0	0
PH1100-1-INV	Jeana	0	4	5	1	0	10
PH1100-1-INVF	Jeana	18	4	5	3	5	17
PH1100-1-RCD	Jeana	4	1	0	0	0	1
PH1100-1-RCDW	Jeana	4	4	5	3	4	16
PH1100-1-RCJW	Jeana	0	0	0	0	0	0
PH1100-1-VBW	Jeana	10	4	5	3	4	16
PH1100-1-VC	Jeana	15	4	5	3	5	17
PH1100-1-VCW	Jeana	8	4	3	0	0	7
PH1100-MU-L-1	Jeana	0	4	5	3	5	17
PH1100-MU-R-1	Jeana	0	4	5	3	1	13
PH1100-MUR-EN	Jeana	0	0	0	0	0	0
PH1100-RW-LEFT-W	Jeana	1	4	3	0	0	7
PH1100-RW-RIGHT-W	Jeana	15	4	5	3	5	17
PH502	Jeana	41	16	20	12	20	68
PH502-1	Jeana	45	12	15	9	15	51
PH502-10	Jeana	3	4	5	3	0	12

The **Summary** page can have columns added after the "H" column. The "B", "E", "F", "G", and "H" columns have values populated into its cells via the Update button on the top left of the table.

IV. Rules

The information on the **Rules** page is used elsewhere in the tool using the VLOOKUP function. Columns should be added to the far-right of the table, if needed. Inserting columns between columns with existing values can cause the incorrect value being returned for the places where VLOOKUP is being used.

V. Exclusion

The Exclusion sheet only exists to have a list of non-working days excluded from the date cycle generation when the Select Range button is used on the Analysis sheet. The Select Range button will only evaluate the dates up to the last shaded cell in that list. Replace old dates with newer ones, as needed.

Populate Qty Field process

This process will populate the table with the sum of the quantities due for a given part on a given date.

This routine will first refresh the table containing data exported from Exact MAX. It will look for the source data in: **C:\MRP Data\mrpnav**. **It is imperative that the XML file name is "mrpnav" and that it is saved in a folder named "MRP Data" in "C:\".** All order numbers less than 50,000,000 are then deleted from the record – these orders are not in production. A pivot table on the "Pivot" sheet sources its data from the Data sheet and filters all the available information down to: Current date, Part ID, and Quantity Due. This table is refreshed automatically. Though there are multiple instances of the same dates and the same parts, there is a unique pair of date-part. This is because the Quantity Due column shows the sum of the total quantity due of a part for a particular day. In other words, if there are *several* orders of the *same* part due to be completed on the *same* day, the sum of all the parts across those orders are what you will find under the Quantity Due column.

Now, the routine will cycle through every "Ship" and "Braze" row on the Analysis sheet for each column; the columns contain working days and the rows contain part IDs. Each part ID and date from the Analysis sheet is evaluated against every date-part pair on the Pivot sheet until a match is found, at which time, the Quantity Due value from the Pivot sheet is retrieved and written into the corresponding cell on the Analysis sheet. The "Braze" row is populated by writing the same value into a column that is 'X' places less the column in which the value was inserted into the Ship row. The 'X' value is the lead time. For the purposes of this tool, lead time is defined as the amount of time required to fully process a part *after* it has been brazed (aggregate time required to go through: wind tunnel, testing, plating, and inspection).