Lessons for production management for MTO
Using G-Sim Simulator

Presented By: Oded Cohen
Date: 9th June, 2014
Contents

- Introduction to GSim
- Plant 10 – the base line
- Using GSim for MTO Planning
- Conclusion
Introduction

The Goldratt Simulator (GSim) was built by Eli Schragenheim in 1986 on the base of the computerized OPT game that he developed in 1984. The GSim played a significant role in educating generations of Jonahs and TOC managers around the world.

The objective of this workshop is to re-introduce the Gsim to the TOC community and to show how it can be used for transferring the most updated TOC knowledge for managing MTO production and operations.

The workshop will present how to use the GSim for transferring the understanding of how to manage MTO environment using the TOC injections.
Using Gsim for MTO Planning

Overall structure of the Planning Workshop

- Introducing GSim
- Run #1 – managing the intuitive way
- Analyzing Run #1 - Introducing MTO Injection-1
- Preparing for the 2nd run
- Run #2
- Analyzing Run #2 – Introducing Injection 2
- Run #3
- Summary

Additional Workshops:
- Managing Execution the TOC Way – Injections 3,4, 6,7 (and 8 when applicable) – using GSim
- Material Management - MTO Injection #5 (not supported by GSim)
Starting the Simulator

Instructions to the program participants:

• Turn to your PC
• Open Gsim folder
• Click on Gsim – the program
• Select params.10

GSim can be obtained by purchasing Production the TOC Way by Goldratt & Schragenheim
The Flows of a Commercial Business

The Goal: To make money now and in the future

Gsim provides a system with the three flows

Management / Workforce

Decisions Flow

Information Flow

Process flow

Goal units $
3 products - the customers are prepared to order:

- A - 40 units @ $180 each
- D - 80 units @ $240 each
- F - 40 units @ $180 each

There is some WIP

5 types of resources - 8 Full Time Employees/Machines

Materials to be purchased (released) for production. Need to pay cash.
(A-$30, C-$35, E-$30, F-$65)

The is amount of money in the cash.

Customers pay cash upon delivery

You are the management team

Only time and profit have to be managed - quality is a given

Your assignment is to achieve a target profit (> $4000) and deliver units on time.
Week: 1  Day: 1  Time: 00:00
Cash: 2500  Fixed Exp: 11000
Pace: 1
FREEZE

Machines/Resources

Plant 10

Set up

15  idle
120  idle
60  idle
0  idle
30  idle
0  idle

Demand

A
40
0
9  18
8  0
7  20
6  15
5  15
4  25
3  8
2
1
RM

Process Flow

D
80
0
7
28
15
20
12
9
0

F
40
0

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This is one resource with 120 minutes set up

Job/Step A1 is processed by the GREEN m/c and each unit takes 4 minutes to be processed

The GEEN m/c was assigned to perform job A1

10 units of RM A were purchased (released to production)
The group is split into teams of 2.
20 minutes are given for planning the production for a week.
Run #1 is done under the guidance of the tutor.
Pace: day 1 – pace 1, day 2 – pace 2, day 3-5 – pace 3.
By the end of each day – accumulative Throughput should be recorded by each team.
By the end of the simulated week:
Recording the performance on the result sheet.
Gsim – Assigning Resources and Purchasing
Gsim – End of the Day (days 1-4)
Gsim – Managing the Flow during the Week

<table>
<thead>
<tr>
<th>Sim 10</th>
<th>Throughput</th>
<th>RUN #1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
<td>Day 2</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1150</td>
<td>1150</td>
</tr>
<tr>
<td>2</td>
<td>690</td>
<td>3795</td>
</tr>
<tr>
<td>3</td>
<td>1015</td>
<td>3480</td>
</tr>
<tr>
<td>Average</td>
<td>952</td>
<td>2808</td>
</tr>
</tbody>
</table>

Link to excel file
End of the Week Results – Plant #10 – Run #1

Financial Statement:

- Net Profit: 3710
- End Of Week Cash: 7795
- ROI (annual basis): 37.91%
- Throughput: 14710
- Sales: 23620
- Inventory RM Value: 1140
- Operating Expenses: 11000

Resource Utilization:

<table>
<thead>
<tr>
<th></th>
<th>Break</th>
<th>Prod</th>
<th>Set-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue</td>
<td>-</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Green</td>
<td>-</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>Cyan</td>
<td>-</td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>Red</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Magenta</td>
<td>-</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>Brown</td>
<td>-</td>
<td>36</td>
<td>-</td>
</tr>
</tbody>
</table>

Product | Weekly Demand | Sold |
---------|--------------|------|
A        | 40           | 40   |
D        | 80           | 38   |
F        | 40           | 40   |
### Gsim – Recording the Flow during the Week

<table>
<thead>
<tr>
<th>Group</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>OE</th>
<th>RUN #1 NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1150</td>
<td>1150</td>
<td>4600</td>
<td>7150</td>
<td>10140</td>
<td>11000</td>
<td>-860</td>
</tr>
<tr>
<td>2</td>
<td>690</td>
<td>3795</td>
<td>4600</td>
<td>13460</td>
<td>16450</td>
<td>11000</td>
<td>5450</td>
</tr>
<tr>
<td>3</td>
<td>1015</td>
<td>3480</td>
<td>4975</td>
<td>6010</td>
<td>13200</td>
<td>11000</td>
<td>2200</td>
</tr>
<tr>
<td>Average</td>
<td>952</td>
<td>2808</td>
<td>4725</td>
<td>8873</td>
<td>13263</td>
<td>11000</td>
<td>566</td>
</tr>
</tbody>
</table>

\[ NP = T - OE \]
\[ NP = Sales - RM - OE \]

*RM is calculated only of the goods sold!*

[Link to excel file](#)
GSIM – Plant 10 – Run #1 - Analysis

- Production Management – plan and execute
- The objective – OTIF – On Time In Full
- DDP – Due Date Performance should be major measurement for the production environment.

- Has the target NP been achieved?
- What was DDP?

Let’s implement the TOC solution!
TOC Direction of the Solution

Low Performance Measurements

High Performance Measurements

Current Reality

Future Reality

TOC Injections

TOC direction of solution

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Managing the TOC Way:

- The Basic Assumptions
- The Flows within the system
- The Constraint
- Types of Constraints
- Managing through the Constraint
- The Five steps of Focusing
The TOC Pivot – Managing Constraints Using the 5 Steps of Focusing for Planning

Step 1 - Identify the constraint of plant 10:
- The Primary Constraint is determined by the potential amount of customers’ orders (COs) the plant can get (NP=9,800)
- Secondary Constraint is Capacity. Perform load analysis

Step 2 – Decide how to exploit the system constraint:
- Deciding on the product mix
- Building a delivery plan (determining delivery dates)

Step 3 – Subordinate
- Planning the release Work Orders (WOs)

These steps are incorporated into the TOC Solutions for MTO
The MTO Solution
TOC Solution for MTO

Tactics: The Operations (Production) implements S-DBR and BM to achieve a very high Due Date Performance

Mindset:
Customer orders are the Prime Driver for managing Operations (Production)
The Drum

Immediate improvements in DDP
Due Date Performance
Injections 2-5

Continuous improvement
POOGI
Process of Ongoing Improvement
Injections 6-8

Injection 1
Achievement of the delivery commitments is established as a Prime Measurement for the production area
Injection essence

DDP the prime measurement.

A critical prerequisite is planning of the promised delivery to the customers.
The Delivery Plan is the DRUM.
Preparing for Run #2

Let assume that Sales and PPC have agreed on the weekly delivery to the clients:

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>DD - Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>A</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>F</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>A</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>D</td>
<td>35</td>
<td>38</td>
</tr>
</tbody>
</table>

This delivery plan:
- Brings value of over 5000 NP (?)
- Is realistic (check)
- Risky?
**Injection 1**
Achievement of the delivery commitments is established as a Prime Measurement for the production area

**Preparing for Run #2**

PPC has to convert CO - Customers’ Orders into WO – Work Orders
For simplicity – let’s assume every CO has one Work Order

<table>
<thead>
<tr>
<th>Product</th>
<th>WO #</th>
<th>Quantity</th>
<th>DD - Hour</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>WO1</td>
<td>10</td>
<td>8</td>
<td>WIP</td>
</tr>
<tr>
<td>A</td>
<td>WO2</td>
<td>10</td>
<td>10</td>
<td>WIP</td>
</tr>
<tr>
<td>D</td>
<td>WO3</td>
<td>15</td>
<td>12</td>
<td>WIP</td>
</tr>
<tr>
<td>F</td>
<td>WO4</td>
<td>30</td>
<td>20</td>
<td>F-30</td>
</tr>
<tr>
<td>A</td>
<td>WO5</td>
<td>30</td>
<td>28</td>
<td>A/C – 30</td>
</tr>
<tr>
<td>D</td>
<td>WO6</td>
<td>35</td>
<td>38</td>
<td>A/C/E - 35</td>
</tr>
</tbody>
</table>
### Injection 1
Achievement of the delivery commitments is established as a Prime Measurement for the production area

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### Preparing for Run #2 – Recording the flow of WOs

<table>
<thead>
<tr>
<th>Product</th>
<th>WO #</th>
<th>Q</th>
<th>DD - Hour</th>
<th>Material</th>
<th>Actual released</th>
<th>Q on time</th>
<th>WO completed</th>
<th>DDP</th>
<th>LoS</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>WO1</td>
<td>10</td>
<td>8</td>
<td>WIP</td>
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<td></td>
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<td>A</td>
<td>WO2</td>
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<tr>
<td>F</td>
<td>WO4</td>
<td>30</td>
<td>20</td>
<td>F-30</td>
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<tr>
<td>A</td>
<td>WO5</td>
<td>30</td>
<td>28</td>
<td>A/C – 30</td>
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<tr>
<td>D</td>
<td>WO6</td>
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<td>38</td>
<td>A/C/E - 35</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>
Instructions for Run #2

- **Restart GSim plant 10**
- **Agree on the roles of each member of the team**
- **Prepare the documents for recording**
- **Start the run. Day 1 – pace 2. Day 2-5 – pace 3.**
- **Record:**
  - Release time of WO
  - Quantity delivered at the planned DD
  - If WO is not completed – record the completion time
  - Calculate LoS – Length of stay
- **Record end of the week results. Calculate DDP.**
Gsim – Results – Plant #10 – Run #2

Results graph run #1 and #2

PERFORMANCE

TOP SCORE

NP = 4000

RUN #1

RUN #2

Lessons to be learnt
What was blocking you now???
Record & Discuss

Record also the Graph of DDP
Preparing for Run #3

Do you want to make any changes to the Shipping Schedule?
Make the changes.

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>DD - Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>10</td>
<td></td>
</tr>
<tr>
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<td>10</td>
<td></td>
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<td>D</td>
<td>15</td>
<td></td>
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<td>F</td>
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<td>A</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

This delivery plan:
- Brings value of over 5000 NP
- Is realistic
- Risky?
Injection 1 - Preparing for Run #3
Introducing the delivery plan to the “System” - GSIM

1. Open the planning window
2. Record the delivery of the “free” products
3. Check using: Show Shipping Timing
4. Save the commands file
5. commands.10-1

TICK OFF – the restricted before OK
TOC Solution for MTO

The Operations (Production) implements S-DBR and BM to achieve a very high Due Date Performance

Mindset:
Customer orders are the Prime Driver for managing Operations (Production)
The Drum

Immediate improvements in DDP Due Date Performance

Continuous improvement
POOGI
Process of Ongoing Improvement

Injection 2
Production Buffer (PB) is set to be challenging but achievable, with Raw Materials released accordingly
Planning

Injection 3
Work Orders (WO) sequenced according to buffer status through the use of Buffer Management
Execution Control

Injection 4
BM - Buffer Management for recovery actions is in place

Injection 5
Availability of the selected critical Raw Materials (RM) and components is monitored/managed
Planning & Execution
Injection 2

Production Buffer (PB) is set to be challenging but achievable, with Raw Materials released accordingly.
Injection 2

Injection essence

Injection 2 introduces the concept of the Production Buffer (PB) – what it is and how it is used for managing the production flow.

The injection contains:

1. The definition of Production Buffer (PB)
2. Time status of the PB
3. The size (length) of the PB
4. Material Release – the signal to start working on the order
Injection 2
Production Buffer (PB) is set to be challenging but achievable, with Raw Materials released accordingly

Material Release – the signal to start working on the order – The Rope

The time for the raw material release is given determined by the start time of the Production Buffer.

The length of the Rope equals the length of the Production Buffer

NOT EARLIER!!
Preparing for Run #3

Determining the size (length) of the PB

Inputs:
1. QLT/ Current practice (weekly plans)
2. LoS statistics
3. Routing (back to back)

Please note the limitation of the GSim – it can handle only one size of PB. Hence – do not spend too much time discussing!

Let’s assume PB = 24 hours
Preparing for Run #3 - Material Release

The process determines: Material to be released, quantity and timing.
- Material – through the BOM
- Quantity – using the procedure of “Gross to Net” (mrp)
- Timing = CO DD minus PB

<table>
<thead>
<tr>
<th>Product</th>
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<th>DD - Hour</th>
<th>Material</th>
<th>Timing</th>
</tr>
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<tbody>
<tr>
<td>F</td>
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<td>10</td>
<td>8</td>
<td>WIP</td>
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</tr>
<tr>
<td>A</td>
<td>WO2</td>
<td>10</td>
<td>10</td>
<td>WIP</td>
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<tr>
<td>D</td>
<td>WO3</td>
<td>15</td>
<td>12</td>
<td>WIP</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>WO4</td>
<td>30</td>
<td>20</td>
<td>F-30</td>
<td>0 (20-24)</td>
</tr>
<tr>
<td>D</td>
<td>WO6</td>
<td>35</td>
<td>38</td>
<td>A/C/E - 35</td>
<td>14 (38-24)</td>
</tr>
</tbody>
</table>
Preparing for Run #3

Introducing injection 2 to the “System” - PB

Open the planning window

Load the command file

Introduce PB – called “Shipping Buffer”
Preparing for Run #3
Introducing injection 2 to the “System” – Material Release – using the ROPE

Press the “Rope”
Observe the “Purchase” schedule
TICK OFF – the restricted before OK
Do not use the AUTO Feature!!!
Preparation for Run #3 – Recording the flow of WOs

<table>
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<th>Product</th>
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<th>DD - Hour</th>
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<td>A</td>
<td>WO2</td>
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<td>WO5</td>
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</tbody>
</table>
Instructions for Run #3

- Restart GSim plant 10
- Agree on the roles of each member of the team
- Prepare the documents for recording

What will be different?
- Once you start the simulator – material will be released according to the plan – time and quantity. You will not need to manually purchase material.
- However – if at the time of release there will not be enough money to buy everything – the available money will be used to buy only some and when more money will come – more will be released.
Instructions for Run #3 (cont.)


• Record:
  - Release time of WO – was it on as planned?
  - Quantity delivered at the planned DD
  - If WO is not completed – record the completion time
  - Calculate LoS – Length of stay

• Record end of the week results. Calculate DDP.
Gsim – Results – Plant #10 – Run #3

Results graph run #1 - #2 - #3

PERFORMANCE

- TOP SCORE
- NP = 4000
- RUN #1
- RUN #2
- RUN #3

Lessons to be learnt
What was blocking you now???
Record & Discuss

Record also the Graph of DDP
Conclusion
TOC Solution for MTO – Planning

- The use of GSIM, in a directed way enables the TOC practitioner to enhance the understanding of the injections of the TOC Solution for MTO environment.

- The workshop gives the participants the opportunity to grasp the essence of the injection through hands-on experience. When dealing with practical examples and numbers – the concepts become more “friendly”.

- Many managers tend to leave production planning to their automated system. The perception is that planning is difficult and anyway a waste of time. We can help them realize that planning is simple and worthwhile.

- Good planning provides the base for more effective and less hectic execution management.
The Operations (Production) implements S-DBR and BM to achieve a very high Due Date Performance.

Mindset: Customer orders are the Prime Driver for managing Operations (Production) The Drum

Immediate improvements in DDP Due Date Performance

Continuous improvement POOGI Process of Ongoing Improvement

Injection 1
Achievement of the delivery commitments is established as a Prime Measurement for the production area

Injection 2
Production Buffer (PB) is set to be challenging but achievable, with Raw Materials released accordingly

Injection 5
Availability of the selected critical Raw Materials (RM) and components is monitored/managed

Planning
Oded has over 35 years of experience in developing, teaching and implementing TOC methodology, solutions and implementation processes working directly with Dr. Goldratt all over the world. Among the countries to which Oded brings his expertise are the USA, Canada, Japan, India, China, the UK, Poland, Russia, Ukraine, Colombia, Chile, Peru, Turkey and many others.

Oded has authored multiple TOC articles and contributed to numerous TOC books.


Together with Jelena Fedurko Oded has co-authored the book *Theory of Constraints Fundamentals*.

Oded is International Director of TOC Strategic Solutions Ltd and Founder and Co-President of TOCPA.