2002

High Definition Manufacturing Cell Model

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Leupold & Stevens, Inc.

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Model Summary

- Four CNC turning centers
- Plus several smaller pieces of equipment for deburring and finishing
- Purpose was to study:
  - Capacity
  - staffing requirements
  - alternative equipment configurations

Model Level of Detail

- Simulates the manufacture of 20 different parts
  - From 8 different sizes of bar stocks/extrusions
- Each part has a unique routing through the cell
  - Some parts require extra deburring or finishing steps
  - Others do not

Preview of Results

- One possible finishing process shown to be a bottleneck regardless of staffing levels
  - Tumbling followed by bead blast
- This further motivated the search for alternative processes
  - An alternative process was found
  - The model showed it would not be a bottleneck
- The model also showed that three operators could run the cell
  - Contrary to expectations of process engineer
  - Later validated in actual operation

Leupold & Stevens

- Leading manufacturer of high quality riflescopes
  - Used by hunters and competitive shooters
- Founded in 1907
  - Began producing current line of products in 1947
- Currently exploring Lean manufacturing
  - After decades of using traditional batch processing
    - where parts are manufactured and finished in large batches
    - and stored in a stockroom before being issued to final assembly work orders

A New Product, the CQT, was being Developed

- Became a demonstration product for Lean manufacturing
- Substantial investment
  - Unique metal parts to be built on a daily basis…
  - In response to the immediate assembly needs
- After fabrication in the CNC turning center, parts also require additional operations
  - To achieve the desired surface finish
  - Some of this processing is done within the cell

Potential Process Bottleneck

- After fabrication and partial finishing, parts then go to a subcontractor
  - Located 17 miles away
  - Who “anodizes” the parts
  - To make the aluminum black and tougher
- Two to three days later, the parts return
- They are built into finished products within another two or three days

Throughput Goal

- One week
  - From barstock to finished product
- Very aggressive
  - Since historical throughput times range from 6-10 weeks

ProModel Model

- Would it be feasible to build one day's worth of parts every day?
  - By setting up a highly efficient "rotation" through the parts
- There was concern about the finishing process for the external parts
  - Called "tumbling"
  - Would this prove to be a major bottleneck?

Modeling Challenges A

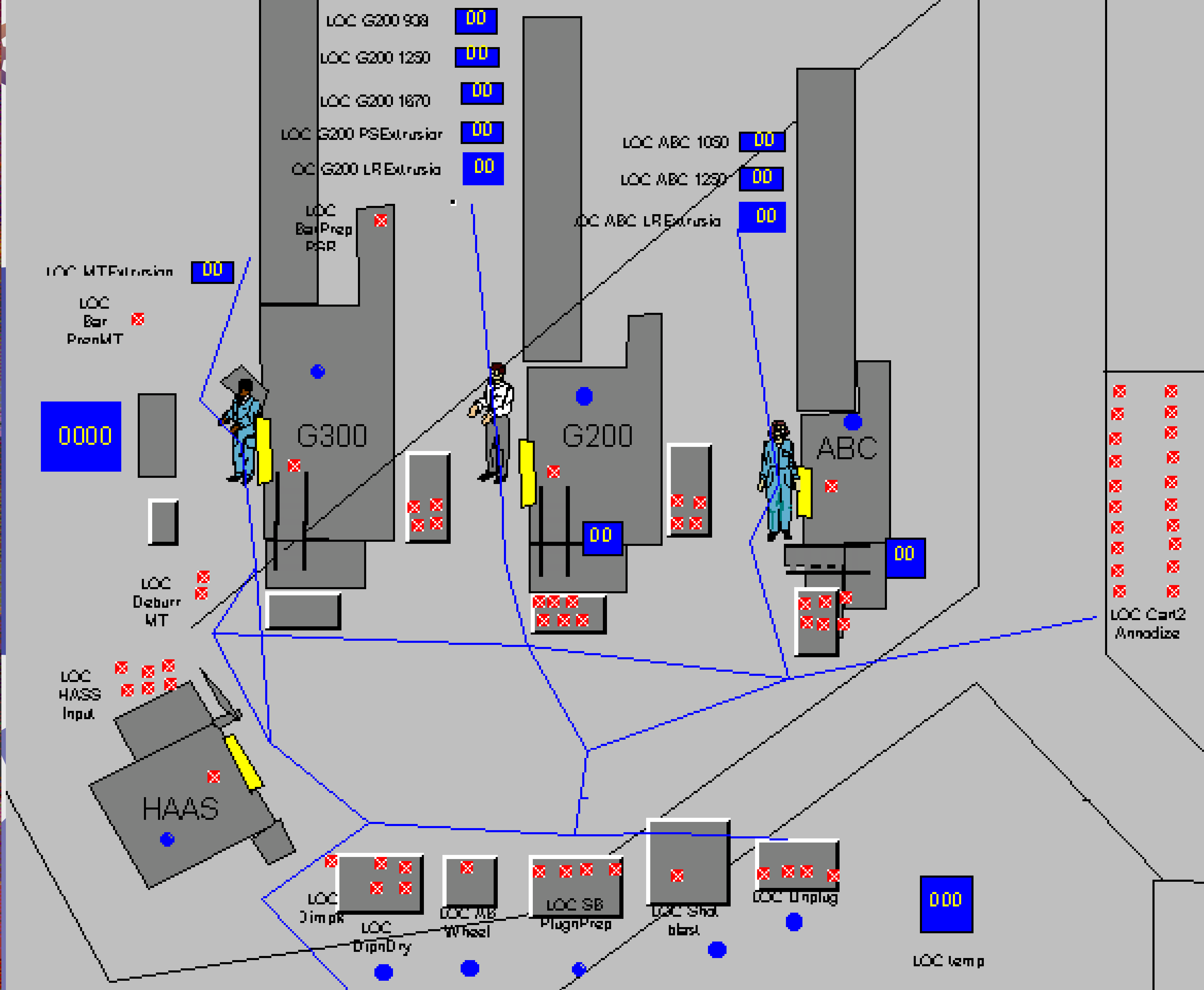
- To write a substantial subroutine
- That simulates the actual cutting of parts from raw material
  - loading another bar stock when needed
  - changing to the next part number once the daily quantity is completed
  - determining whether or not the next part requires a material change
  - etc.

Modeling Challenges B

- To enhance the processing logic
  - So that the model can run through the parts rotation forwards or backwards
    - as is done in the real world
    - to avoid a part changeover at the start of each rotation
- To correctly specify the priority logic
  - To indicate which tasks are done by each resource

Additional model features

- Realistic animation
  - Not just for the operators as they carry out the various tasks
  - But also for the trays of parts as they are processed
  - And accumulate, prior to going to the subcontractor
- Spreadsheet data links
  - For process cycle times, setup times, and material consumption amounts
  - To allow for the possibility of live linkages to the process data stored in the company’s MRP system



LOC G200 908
00
LOC G200 1250
00
LOC G200 1670
00
LOC G200 PSExtrusior
00
OC G200 LR Extrusio
00
LOC ABC 1050
00
LOC ABC 1250
00
OC ABC LR Extrusio
00
LOC BarPrep PSR
LOC MTExtrusion
00
LOC Bar PrepMT
0000
G300
G200
ABC
00
00
LOC Deburr MT
LOC HASS Input
HAAS
LOC Cart2 Anodize
LOC Dimpk
LOC DipnDry
LOC MB Wheel
LOC SB PlugnPrep
LOC Shot blast
LOC Unplug
000
LOC temp

```
IF OWNEDRESOURCE() < 1 THEN GET RES_G200 OR RES_Flex
IF V_NEWPN = 1 THEN     //need to do changeover
  {
    WAIT ARR_G200ChgOvrTimes[V_PN + V_Offset]
    V_G200ChgOvrTime = V_G200ChgOvrTime + ARR_G200ChgOvrTimes
    A_Length = A_Length - ARR_G200SetupPartsPerChg[V_PN] * ARR_G2
    V_NewPN = 0
  }
ELSE WAIT M_BarChgTime
IF V_PN = 10 THEN SEND 1 ENT_PSExtrusion TO LOC_BarPrepPSR
FREE ALL
startofloop:
   IF V_QtyBuilt < M_KANBANQty THEN
     {
       IF A_Length < M_MinBarLength + ARR_G200FTPerPart[V_PN] THEN
         {
           ROUTE 1
           RETURN
```

```
    }
    ELSE SUB_G200MakePart()
  }
ELSE
  {
    V_PN = V_PN + V_Dir              // get ready to make next part
    V_QtyBuilt = 0
    IF V_PN = 0 THEN GOTO done
    IF V_PN > 1 THEN IF ARR_G200LastPart[V_PN - 1] = 1 THEN GO
    IF ARR_G200NewMtl[V_PN + V_Offset] = 1 THEN
      {
        V_NewPN = 1
        V_Route = ARR_G200StartVRoute[V_PN]
        ROUTE 2 +V_Offset       //need to do changeover; offset is adde
        RETURN
      }
    ELSE
```

```
{
V_Route = V_Route + V_Dir    // increment or decrement which route to ta
IF A_Length < M_MinBarLength + ARR_G200SetupPartsPerChg[V_PN] *
  {
    V_NewPN = 0    //bar is not long enough to setup new part, need to ge
    ROUTE 1
    RETURN
  }
ELSE
  {
     GET RES_G200 OR RES_Flex      //bar is long enough to do changeov
     WAIT ARR_G200ChgOvrTimes[V_PN + V_Offset]
     V_G200ChgOvrTime = V_G200ChgOvrTime + ARR_G200ChgOvrTim
     A_Length = A_Length - ARR_G200SetupPartsPerChg[V_PN] * ARR_
     FREE ALL
     SUB_G200MakePart()
```

```
            }
         }
      }
    GOTO startofloop
done:   //should get here only if done with a day's schedule
V_G200_On = 0
V_G200_Done = CLOCK(HR)
WAIT UNTIL V_G200_On = 1
V_DIR = V_Dir * (-1)
V_PN = V_PN + V_Dir
IF V_Offset = 0 THEN V_Offset = 1 ELSE V_Offset = 0
V_NewPN = 0
WAIT 1  // so as to not grab worker before they can unload the last handfu
GOTO startofloop
```

Model Validation

- Modeler and process engineer carefully watched the animation to assure that
  - Each part is correctly routed
  - Operators perform the work in the correct sequence
- Variables included to allow collection of data needed for validation
- Many potential problems identified & corrected
  - E.g., with the resource/priority specifications in the operation/routing logic

Initial Results: Tumbling Not Good

- Modeling the tumbler was a challenge
  - It contained four cylinders, but only one door
  - The cylinders rotated, with one of them being at the door position at any given time
  - Further, the media in the tumbler had to be washed after every other tumbling run
- The model clearly showed that this would be a major bottleneck
  - And, further, that the problem could not be resolved through optimal operator behavior
- The process was abandoned.

Enter “Shot Peening”

- A different finishing process,
  - Identified by the Manufacturing Engineer
- Much easier to model this process
  - Was quickly shown to be vastly superior
- The equipment was ordered
- The process has proven not to be a bottleneck operation

Staffing Analysis Results

- Three operators should be able run the cell effectively
  - Assuming that the part changeovers could be done in the prescribed time
  - Operators would be kept quite busy, however
    - perhaps busier than their counterparts in the rest of the factory
- Four operators were hired
  - To be on the safe side
- During subsequent months, the production cell often had to run with only three operators
  - They were able to do so quite effectively

Was Daily Part Rotation Feasible?

- The model clearly said No
- This same conclusion was reached using spreadsheet analysis
  - But seeing it in the model was more compelling
- It also showed that a 2-day rotation would work
  - The rotation could be accomplished by running two days worth of parts at a time
  - The process engineer knew that this was theoretically possible
  - But seeing the model results increased his confidence that it could actually be done
- Subsequent operations validated this result

Sample Model Results

- Resource Utilization %
  - RES G300 68.52
  - RES G200 52.54
  - RES ABC 55.37
  - RES Flex 84.73
  - RES G300S 42.70

One Year Later

- Model resurrected to evaluate a swing shift to increase capacity
- Model had to be enhanced significantly
  - Because swing shift would have less operators
  - And would have different objectives
- Management objective: explore alternative staffing and operating rules
  - How many operators would be needed?
  - Should all three primary machines be run at once?
  - Or, should only two machines be run at a time?

More Modeling Challenges

- To update the priority logic to accommodate two shifts with different staffing levels
  - Different operators perform the tasks on swing shift compared to day shift
  - Thus, the resources used on day and swing had to be different
  - And, much of the operation and routing logic had to be modified
- It was difficult to get the downtime logic to work correctly for Locations
  - Resource downtimes worked fine

More Model Validation

- The addition of second shift logic required careful re-validation
  - To assure that parts continued to move realistically
  - The previous validation done for day shift logic was irrelevant and had to be repeated
    - Since totally different resources are used on the second shift

Second Shift Analysis Results

- Two operators would need to run all three machines for a couple of hours
  - But would only need to run two machines for most of the shift.
- One operator could almost, but not quite, run the cell by himself
  - With only slightly reduced output
  - Giving an indication of what could be done when one second shift operator is not available
- Overall, the parts manufacturing cell would have some excess capacity