Ogden Air Logistics Center

Developing a Model for Planning Your Project's Schedule

Understanding the Difficulties with Statistically Managing Schedules

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- **Agenda**
  - **Review of Project Planning**
    - **Includes one way to view Schedule Variance**
  - **Results of trying to apply statistical management concepts, and to model, my Project's Schedule**
  - **The rest of the story… & Conclusions**

Review of Project Planning and Schedule Variance

Understanding difficulty with applying SPC to schedule

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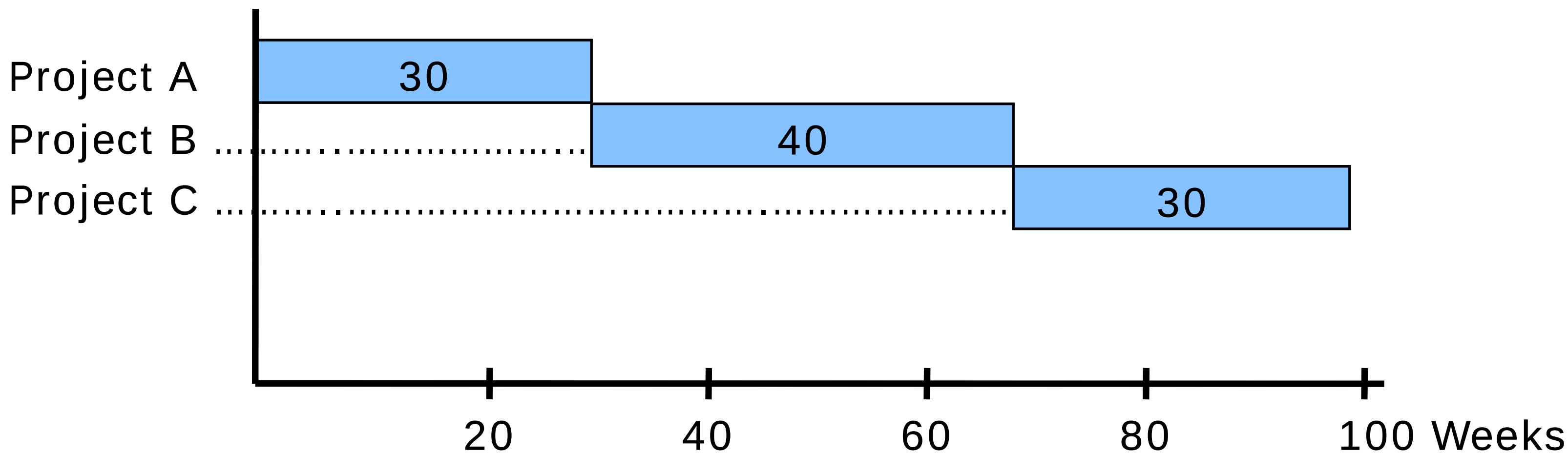
- **To understand the "why" I will review some project planning concepts**
  - **Assume that I have three projects to assign to one engineer**
    - **Proj A = 1200 labor hours / 40 hrs/week = 30 weeks**
    - **Proj B = 1600 labor hours / 40 hrs/week = 40 weeks**
    - **Proj C = 1200 labor hours / 40 hrs/week = 30 weeks**



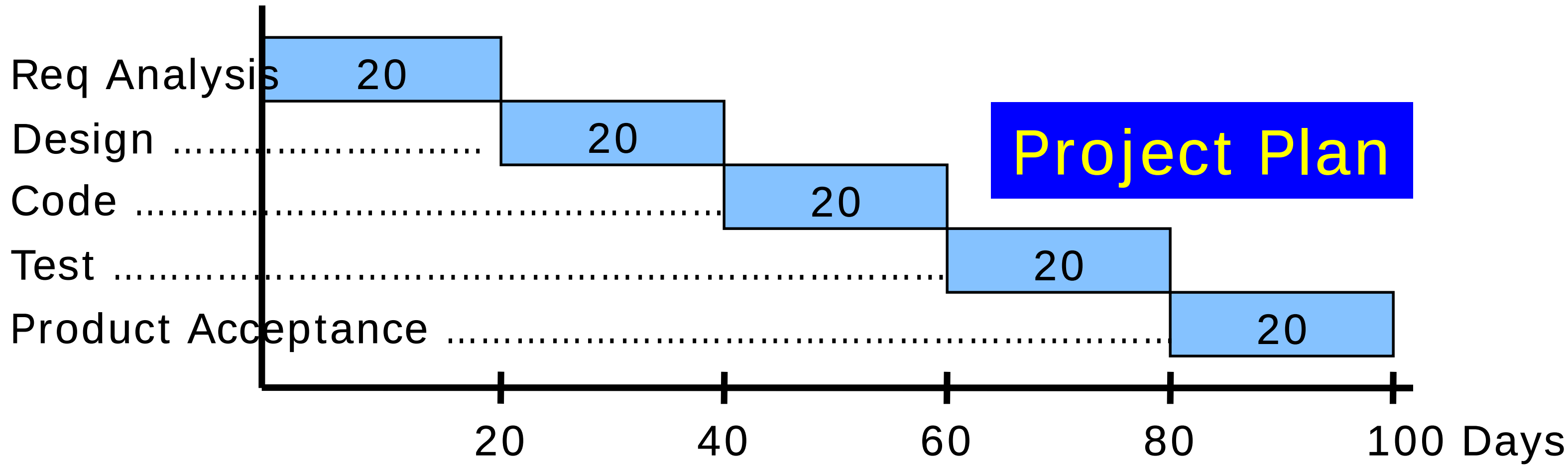
  - **What are some of the problems with planning a schedule in this manner?**

What is Real Life in your Organization?

- Do your employees spend their entire day every day dedicated to and working *(i.e. no slack time, no multi-tasking)* on the project's current task?
- Do all of your employees work the same number of hours each day (No overtime, SL, AL, compensatory time, etc.)?
- Are your employees free from other interruptions, such as meetings, training, phone calls, reading email, etc.?
- Can all of your projects be worked in a pure waterfall manner with no overlapping of tasks?

- If you answered "Yes" to all of the above then perhaps applying SPC to your projects' scheduled days will work

A Simple Waterfall Schedule



Planned Schedule Performance (PSP) = 100 Days
Let Actual Schedule Performance (ASP) = 125 Days

One way to look at this is that the project was delivered 25% over schedule.

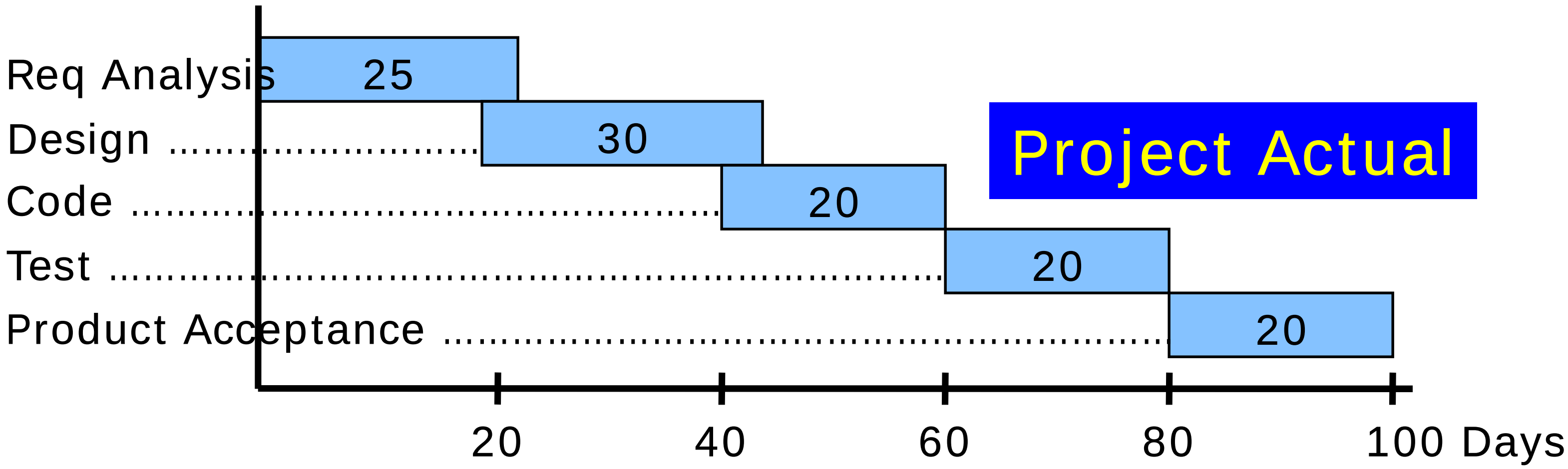
Schedule Variance = (PSP – ASP) / PSP = -25/100 = -25%

Results like this may result in something like a CAR or a DMAIC action to address the project planning process/subprocess to improve the accuracy of future project plans

Pre-analysis
Understand the Data

- We will discuss tonight's dinner as an analogy to understanding the schedule data. I want to purchase filet mignon for dinner tonight and I estimate that dinner will cost $25. Can I afford it? How much money is in my wallet?

Let's Look at a Simple What If Scenario

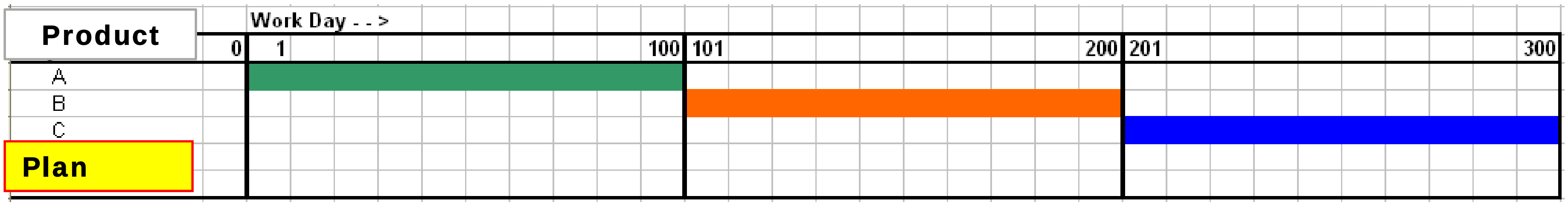


Planned Schedule Performance = 100 Days
Actual Schedule Performance =

  25 Days for Requirements Analysis
+ 30 Days for Design
+ 20 Days for Code
+ 20 Days for Test
+ 20 Days for Product Acceptance
= 115 Days

So adding up the sum of the days for each subprocess does not always equal the total number of calendar days spent on the project. In this simple example fifteen calendar days were counted twice.

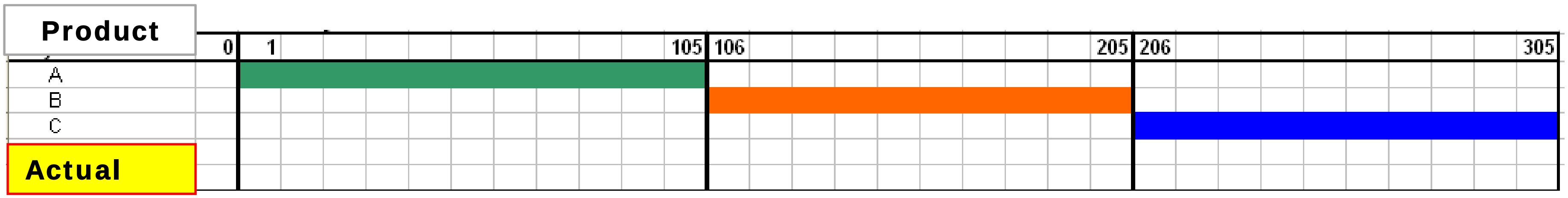
Simple Waterfall Schedule for a project with three deliverables



Scenario 1: The project is the development and delivery of three products that were planned to be worked in a waterfall manner. Each product is scheduled to take 100 days in length

Example continued on the next page

Simple Waterfall Schedule for a project with three deliverables



Assume Product A went 5 days over schedule.

From the <u>customer's</u> viewpoint from the start date

Product A	PSP_A = 100 Days	ASP_A = 105 Days	SV_A% = -5%
Product B	PSP_B = 200 Days	ASP_B = 205 Days	SV_B% = -2.5%
Product C	PSP_C = 300 Days	ASP_C = 305 Days	SV_C% = -1.67%

This raises numerous issues from a Process Improvement viewpoint

Products A, B & C are all planned to be of similar complexity (100 days in length) but if you count the days from the start date then product B appears to be twice the complexity of Product A and Product C appears to be three times the complexity of Product A.

From the viewpoint of process improvement for planning the schedules, the late deliveries of the three products could lead you in the wrong direction. The planned scheduled durations of the 2nd and 3rd products were correct

Example of Actual Labor Hours

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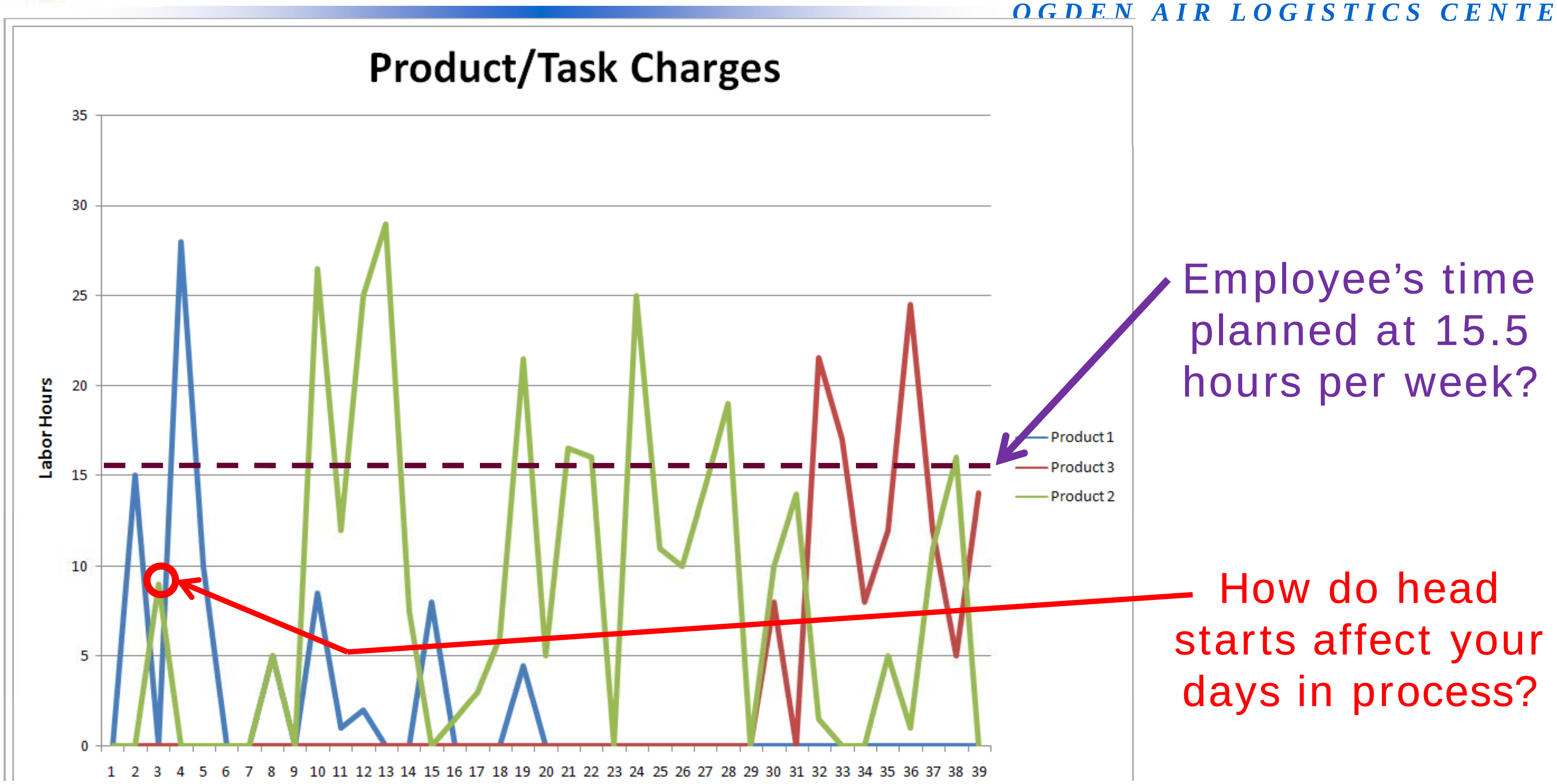


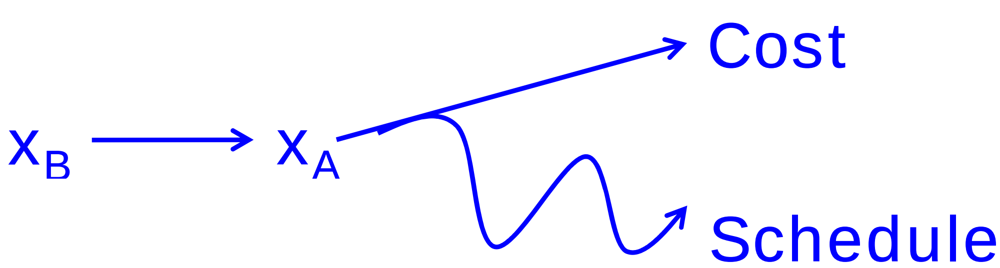
Employee was scheduled to work part-time (50%) on my workload. The products were scheduled to be developed in a waterfall manner. Labor hours do not include time spent on peer reviews of other development products, his other workload, or leave, or training, or …

Results of trying to apply statistical management concepts, and to model, my Project's Schedule

Are you headed in the same direction that I went?

- **Some of you may be very frustrated with trying to statistically manage your schedule. You want to give up, to criticize CMMI, but other than saying "it doesn't work" you cannot answer why.**

- **Through a round about path my efforts at modeling my schedule took me back to some of the same contributors I experienced when I modeled my costs**
  - **And "Yes" I answered why it is difficult, or perhaps impossible, to statistically manage your schedule**

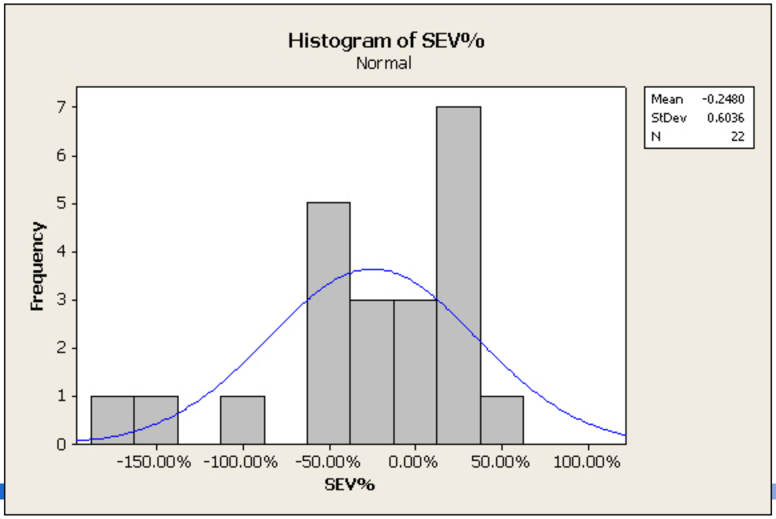


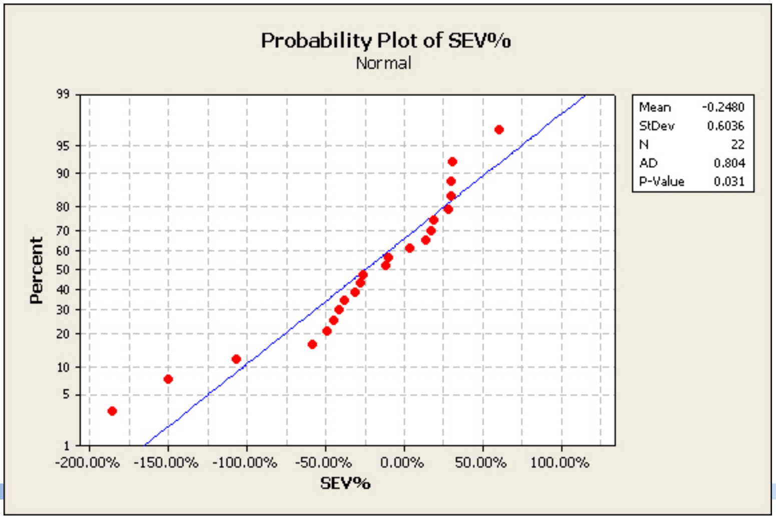
Background

- Wrapping up Current Project
  - ½ of team were new with range of background from no experience to similar experience
  - Each engineer assigned 2 or 3 products which were planned in a waterfall method according to the priority of the product
  - Products consisted of hardware and software
    - Fabrication of hardware was contracted to another source
  - Independent verification/validation and independent test readiness review performed before scheduling 1st of 2 product acceptance procedures
    - Gov reviewed contractor & contractor reviewed government
  - Planned manpower availability ranged from full-time to 50%
- Perceived that modeling the planning process would improve our ability to plan the next two phases
  - Customer waiting for detailed plan

A Look at Schedule Estimating Variance

- **(bid plan – actual) / bid plan**
  - **I experienced problems with the definition of schedule variance**
    - **When does the calendar start? Start of project or start of work on product/task or the planned product/task start date if started late?**
    - **Head starts can make days-in-process exceed planned days**
    - **Do I give partial day credit or full day credit?**
  - **Ripple effect propagated delays to other products**
- **Data was not normally distributed (low p-value < 0.05)**





Individual-moving Range charts for SEV%

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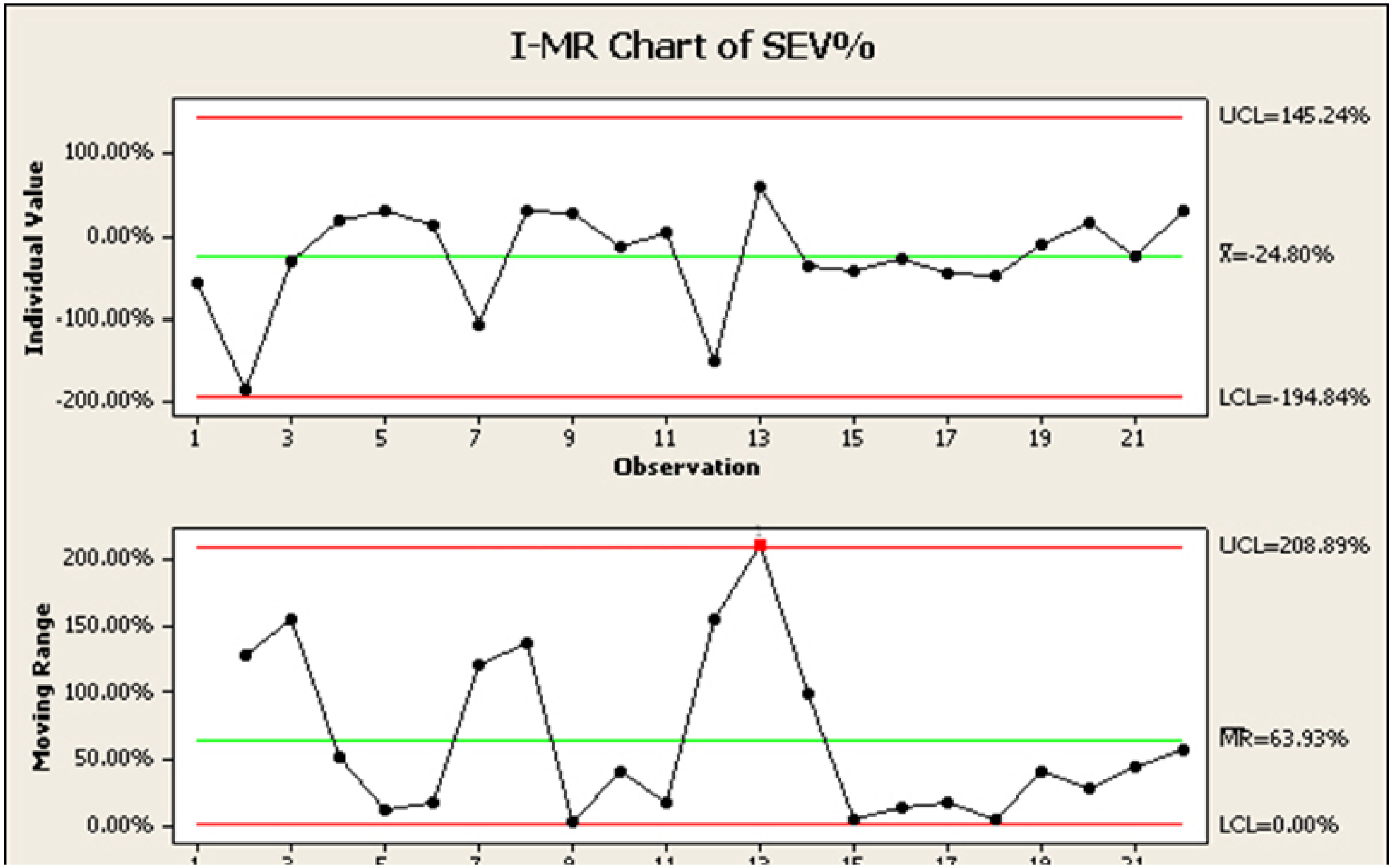

Desire to reduce the variations and improve the plans.
I needed to find a way to address the definition problems mentioned on the previous chart.

Regression Analysis

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Regression Analysis: SEV% versus CEV%, Plan Hr/Wk

```
The regression equation is
SEV% = 0.539 + 0.843 CEV% - 0.0481 Plan Hr/Wk


Predictor       Coef   SE Coef      T      P
Constant      0.5392    0.2761   1.95  0.066
CEV%          0.8435    0.2349   3.59  0.002
Plan Hr/Wk  -0.04806   0.01262  -3.81  0.001


S = 0.396854   R-Sq = 60.9%   R-Sq(adj) = 56.8%


Analysis of Variance

Source          DF      SS      MS      F      P
Regression       2  4.6590  2.3295  14.79  0.000
Residual Error  19  2.9924  0.1575
Total           21  7.6514


Source      DF  Seq SS
CEV%         1  2.3745
Plan Hr/Wk   1  2.2845
```

- This was one of the more promising attempts with
  R-Sq(adj) = 56.8%
- My concern was to avoid implementing a model, such as this one, that would only shift the average towards zero

Analysis of Variance Tests on SEV%

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One-way ANOVA: SEV% versus Plan Hr/Wk

Source	DF	SS	MS	F	P
Plan Hr/Wk	2	3.318	1.659	7.27	0.005
Error	19	4.334	0.228		
Total	21	7.651			

Low P = Difference exists between levels of x.
The "Levels" were the planned labor hrs / week

S = 0.4776   R-Sq = 43.36%   R-Sq(adj) = 37.40%

```
                                Individual 95% CIs For Mean Based on Pooled StDev
Level   N     Mean   StDev    +---------+---------+---------+---------
15.5   13   0.0730  0.3231                             (------*------)
18.6    3  -0.6122  0.4076    (-------------*-------------)
31.0    6  -0.7613  0.7414     (---------*---------)
                              +---------+---------+---------+---------
                            -1.20     -0.80     -0.40     -0.00
```

Pooled StDev = 0.4776

ANOVA Tests on SEV%


```
Session

One-way ANOVA: SEV% versus Plan Hr/Wk

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31.0    6  -0.7613  0.7414         (---------*---------)
                               ---------+---------+---------+---------+---------
                                  -1.20     -0.80     -0.40     -0.00
```

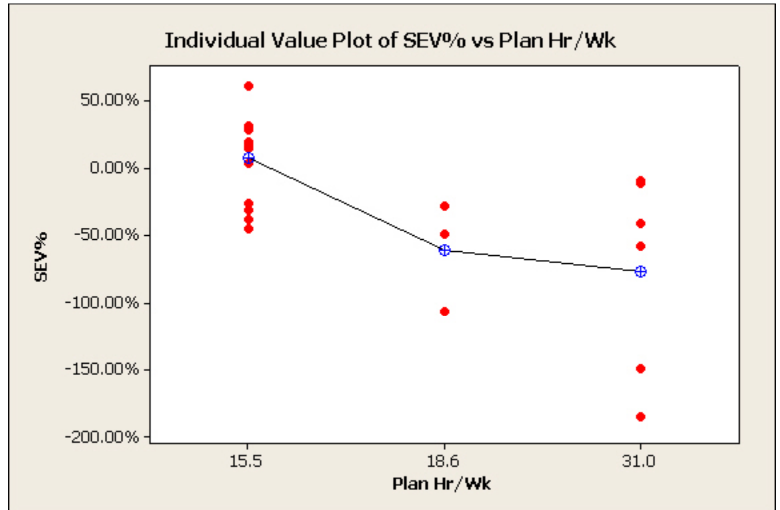

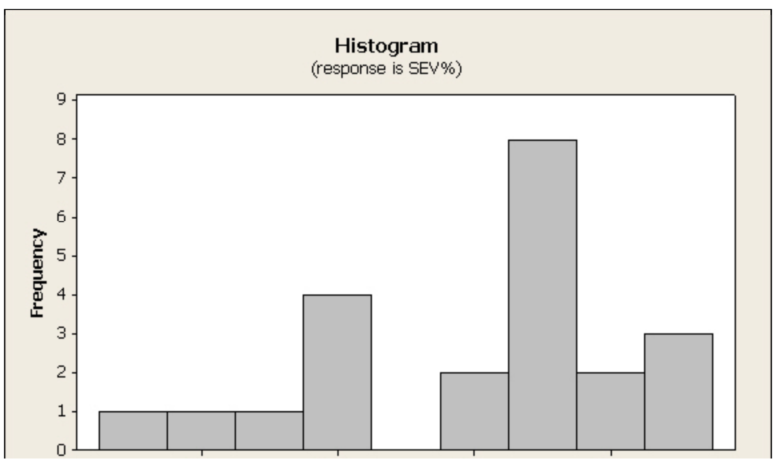

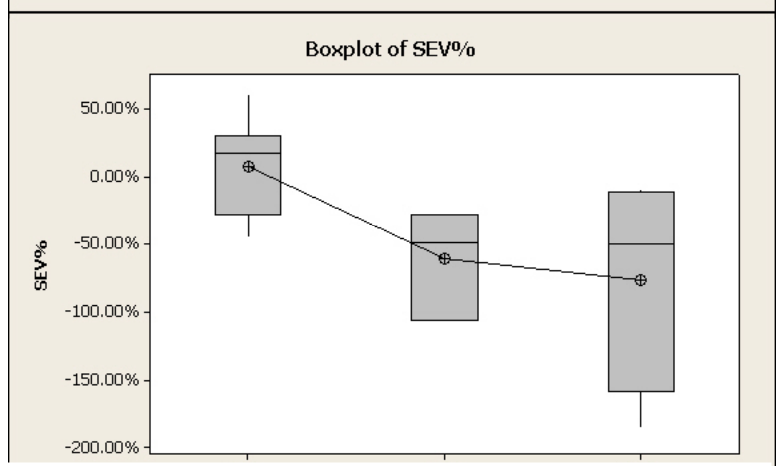

Distribution of data before removing known causes of anomalies

Did you ever feel like you were heading in the wrong direction?

This is the feeling that I had as I continued to look for a way to model my schedule

Relationship between budget and schedule

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- CMMI® PP SP 2.1 refers to the budget and schedule as two different attributes of the product.

- The cost and schedule estimating variance definitions I was using were
  - CEV% = (planned cost – actual cost) / (planned cost)
  - SEV% = (planned sch – actual sch) / (planned sch)

- In the case of many software products
  - Cost = labor hours * sales rate
  - Planned Schedule = (bid labor hours / avg planned labor hours per week) + known delays

Relationship between budget and schedule

- **Modifying my equations I came up with**
  - **CEV = Planned Labor Hours – Actual Labor Hours / Planned Labor Hours = PLH - ALH / PLH**

$$CEV = \frac{\text{Planned Labor Hours} - \text{Actual Labor Hours}}{\text{Planned Labor Hours}} = \frac{PLH - ALH}{PLH}$$

let PAL = Planned Average Labor hours per week

AAL = Actual Average Labor hours per week

- **When I plan the bulk of the workload I plan the schedule as,**

  Planned Schedule Performance = PLH / PAL

- **Actual schedule performance can be defined as,**

  Actual Schedule Performance = ALH / AAL

Schedule variance in terms of labor hours

SEV = (PSP – ASP) / PSP **see slide 6**

Substituting the definitions on the previous page into the equation above I came up with,

$$SEV = \frac{AAL - \left[PAL * \left(\frac{(PLH-ALH)}{PLH} \right) \right]}{AAL}$$

The important thing to note is that my schedule variance is now in terms of labor hours. The benefit is that labor hour charges are not counted numerous times

1st pass not very useful for planning purposes

Session

Regression Analysis: SEV% versus Actual Hrs, Plan Hr/Wk

The regression equation is
SEV% = 1.44 - 0.00170 Actual Hrs - 0.0430 Plan Hr/Wk

Predictor	Coef	SE Coef	T	P
Constant	1.4395	0.3277	4.39	0.000
Actual Hrs	-0.0017032	0.0004858	-3.51	0.002
Plan Hr/Wk	-0.04298	0.01293	-3.32	0.004

S = 0.400674 R-Sq = 60.1% R-Sq(adj) = 55.9%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	4.6012	2.3006	14.33	0.000
Residual Error	19	3.0503	0.1605		
Total	21	7.6514			

Source	DF	Seq SS
Actual Hrs	1	2.8270
Plan Hr/Wk	1	1.7742

Actual Hours is unknown at the time that the project is being planned but this effort reinforced the need to try to develop a model of the product's cost

Breaking down the data

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- My plans were based upon the following assumptions
  - A full-time person would average 31 hours per week
  - A part-time person (dedicated 50% to other work) would average 15.5 hours per week
  - Leads and Subject Matter Experts would average 18.5 hours per week
- Looking at the entire data set gave r-Sq(Adj) values of 56%   (see the previous slide)
- But when I broke the analysis down into distinct data sets…

Look at just the Products planned at 15.5 hrs/wk

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Regression Analysis: SEV% versus Bid Hrs, Actual Hrs, ...

```
* Plan Hr/Wk is (essentially) constant
* Plan Hr/Wk has been removed from the equation.


The regression equation is
SEV% = 0.048 + 0.000741 Bid Hrs - 0.000800 Actual Hrs
       - 0.0040 Act Avg Hrs/Wk in actual window


Predictor                              Coef    SE Coef      T      P
Constant                             0.0481     0.5834   0.08  0.936
Bid Hrs                           0.0007409  0.0008483   0.87  0.405
Actual Hrs                       -0.0008004  0.0009179  -0.87  0.406
Act Avg Hrs/Wk in actual window    -0.00402    0.04062  -0.10  0.923


S = 0.334457   R-Sq = 19.6%   R-Sq(adj) = 0.0%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       3  0.2458  0.0819  0.73  0.558
Residual Error   9  1.0068  0.1119
Total           12  1.2526


Source                           DF  Seq SS
Bid Hrs                           1  0.0361
Actual Hrs                        1  0.2086
Act Avg Hrs/Wk in actual window   1  0.0011
```

Very Interesting!

For those employees planned to work part-time on the project the variation was not caused by the planned average labor hours per week

Look at just the Products planned at 31 hrs/wk

Session

Results for: Worksheet 4 -- looking at only those TPSs planned at 31 hrs/wk

Regression Analysis: SEV% versus Bid Hrs, Actual Hrs, ...

```
* Plan Hr/Wk is (essentially) constant
* Plan Hr/Wk has been removed from the equation.

The regression equation is
SEV% = 0.32 + 0.00007 Bid Hrs - 0.00416 Actual Hrs
       + 0.087 Act Avg Hrs/Wk in actual window


Predictor                            Coef   SE Coef      T      P
Constant                            0.317     1.325   0.24  0.833
Bid Hrs                          0.000069  0.001102   0.06  0.956
Actual Hrs                      -0.004161  0.002361  -1.76  0.220
Act Avg Hrs/Wk in actual window    0.0874    0.1472   0.59  0.613


S = 0.382984   R-Sq = 89.3%   R-Sq(adj) = 73.3%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       3  2.4553  0.8184  5.58  0.156
Residual Error   2  0.2934  0.1467
Total            5  2.7486


Source                           DF  Seq SS
Bid Hrs                           1  1.1017
Actual Hrs                        1  1.3019
Act Avg Hrs/Wk in actual window   1  0.0517
```

Surprised?

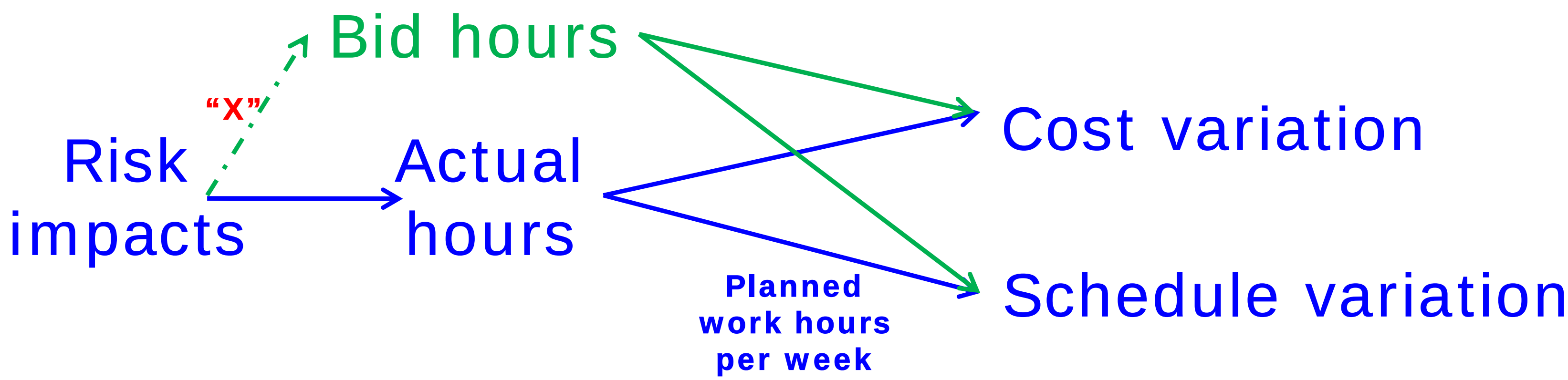
My “full-time” employees were unable to dedicate their time to my project. This quantified a concern that I had been expressing each time a full-time engineer was assigned another task

The rest of the story... Conclusions

The rest of the story… Conclusions

- Statistically managing and modeling your schedule in the manner that it was planned (e.g. avg hours per week) may work better than using calendar days
- The results reiterated the fact that the accuracy of the planned schedule depends upon the accuracy of the bid (i.e. planned labor hours is an “x”, a contributing factor to the variation)
- The next two follow-on phases for my project were planned using the results of trying to model my schedule’s planning process (i.e. realistic average hours of labor per week)
- My change met my goal to shift the average towards 0% schedule variance and to reduce the variation
- And…

The rest of the story… Conclusions



- **Efforts at modeling both cost and schedule variation showed the need to model the bid hours**
- **Efforts at modeling the bid hours are pointing me to the need to model the risk issues**
  - **Future data collection efforts are necessary to better measure impacts from risk issues**

Acronyms

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- **PLH: Planned Labor Hours (i.e. bid)**
- **ALH: Actual Labor Hours for the project or product**
- **PAL: Planned Average Labor hours per week**
- **AAL: Actual Average Labor hours per week**
- **PSP: Planned Schedule Performance**
- **ASP: Actual Schedule Performance**

- **CEV%: Cost Estimating Variance percent**
- **SEV%: Schedule Estimating Variance Percent**

- **CAR: Causal Analysis and Resolution**
- **DMAIC: Define, Measure, Analyze, Improve and Control which could be viewed as a method of implementing a CAR action**

- **AL: Annual Leave**
- **SL: Sick Leave**