Complexity, Productivity, Efficiency and Cost in Digital Production

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More on Complexity

Imagine a complex problem from a few years ago, like naturalistic hair before ILM did "Jumanji" or large scale fluid dynamics simulations before Digital Domain did "Titanic".

Now think about doing those things today. Have the tasks become less complex from a rigorous formal point of view? No. Yet you can do them fairly easily today.

For digital production, we can consider complexity to be the difficulty of doing a particular task. Something that takes 30 hours can be considered more complex than something that takes 10 for instance.

A Case Study:

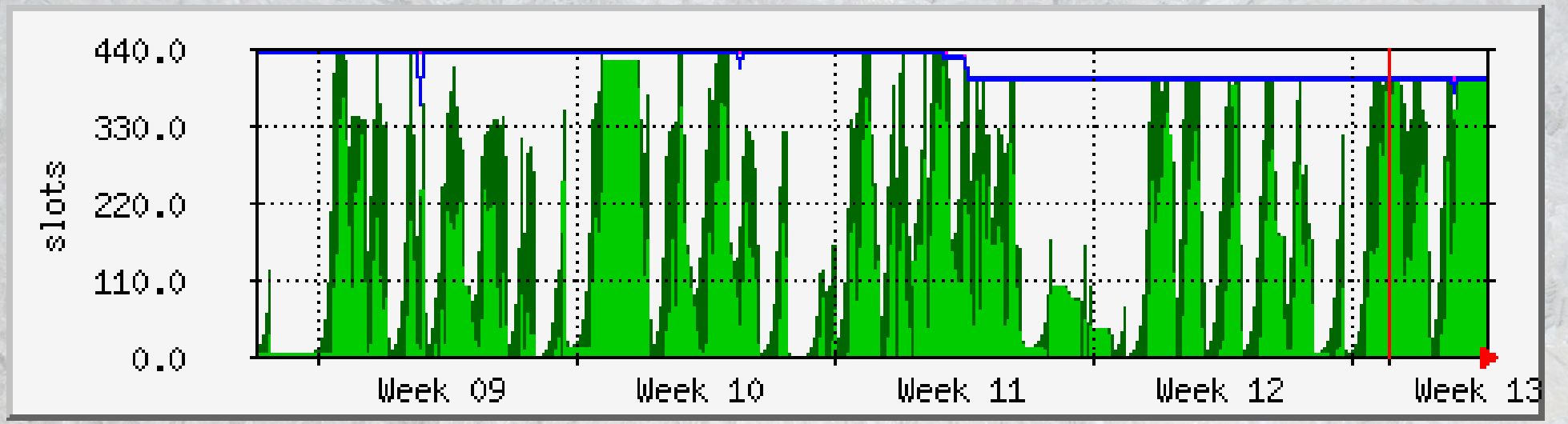
During the first "Lord of the Rings" movie, "The Fellowship of the Ring", Weta was having trouble getting their renders done. Even though they had prodigious computing resources, there wasn't enough to get shots done and the show was falling behind.

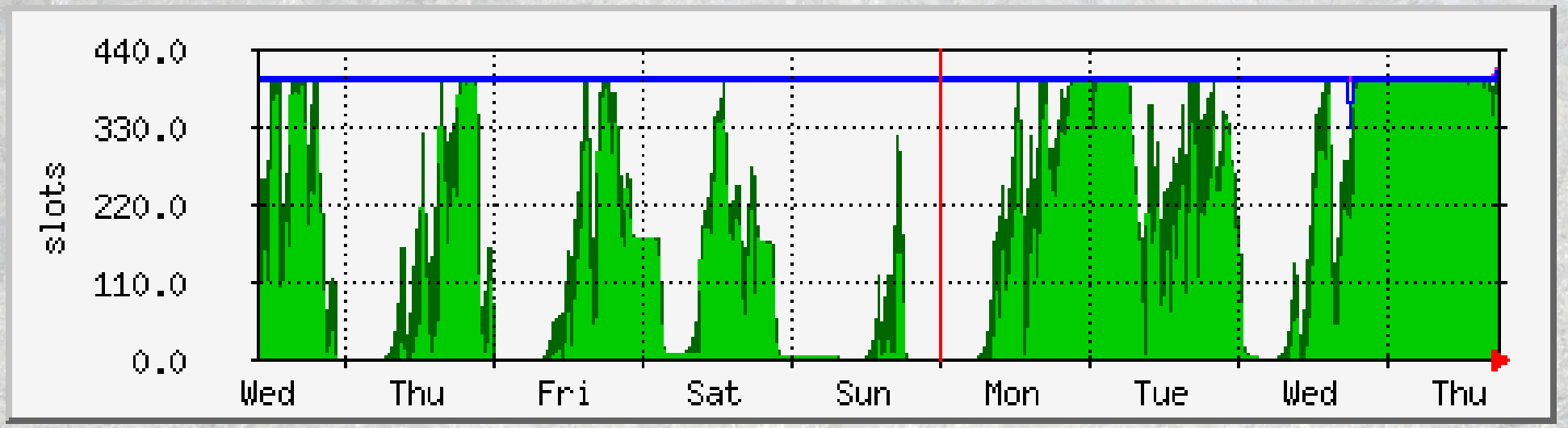
They embarked on a project to optimize renders by making all of their shaders more efficient, being clever about textures and maps and they reduced render times considerably. In addition, they increased their rendering capacity by 25%.

Within three months, the problem was back. They were running out of rendering capacity.

A Case Study:

These are the actual rendering statistics from Alfred.





They show ~30% utilization over time but at the same time they were starved for week day capacity.

A Case Study:

My recommended Solution.

- ✔ *Change Render Management Policy!*
- ✔ *Remove control of render priority from users and supervisors.*
- ✔ *Determine priority by job type.*

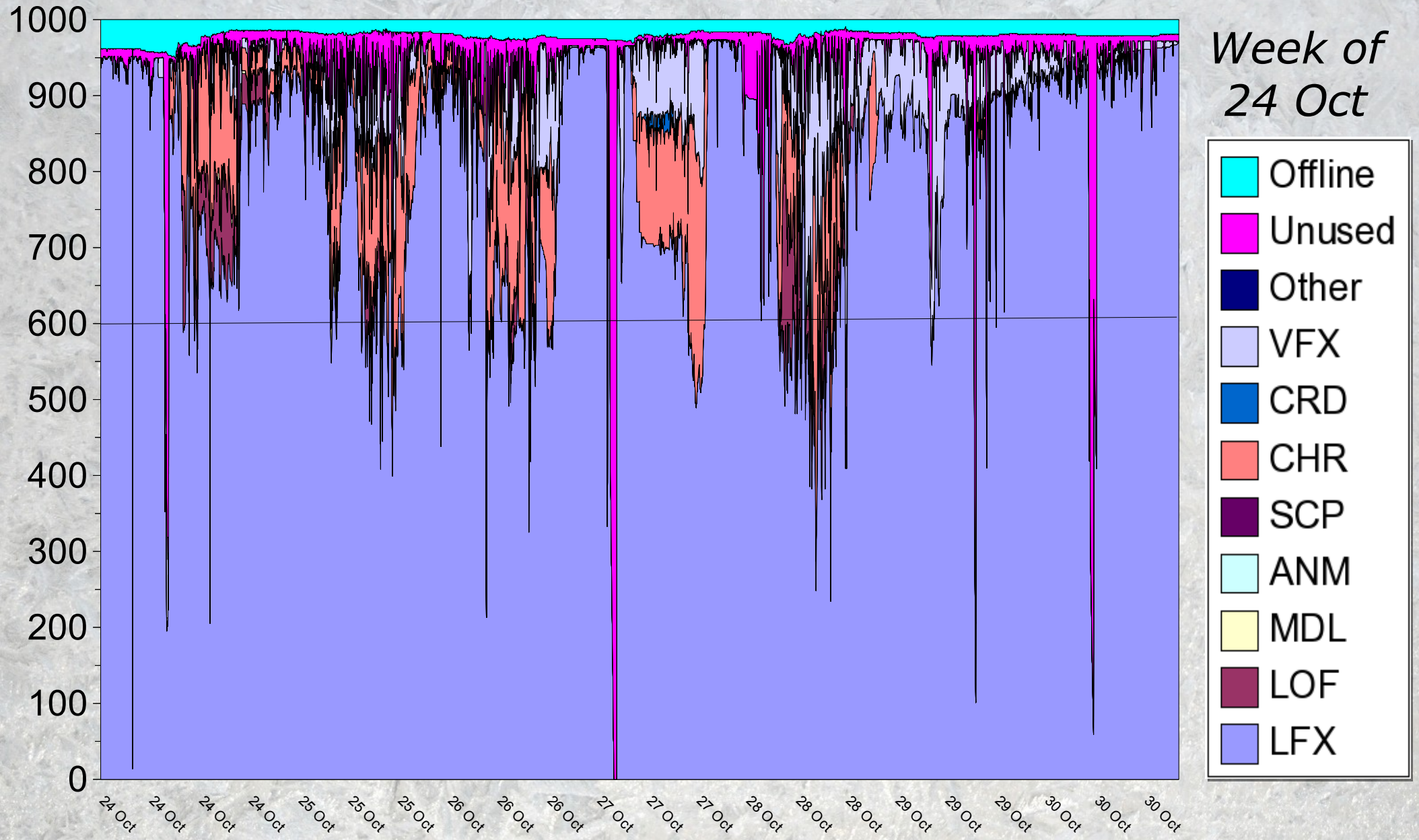
What Weta actually did.

- ✔ *Nearly doubled their rendering capacity from 880 dual proc machines to 1,600.*
- ✔ *10 weeks before the project delivered, they added 1,000 more render machines.*

Are you wondering why? Leads and supervisors didn't believe my solution would work. They were more comfortable working harder rather than smarter.

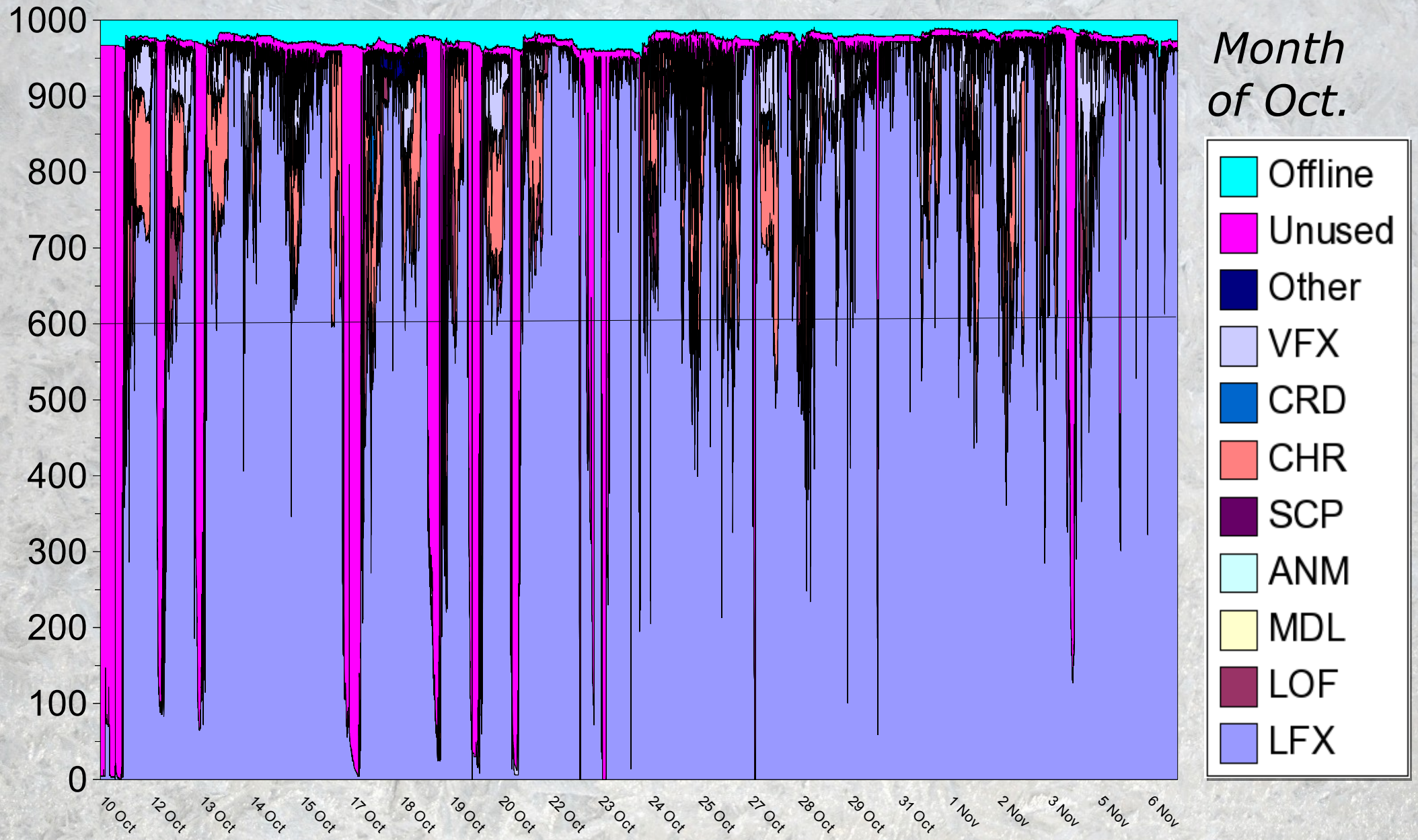
A Case Study:

C.O.R.E. Feature Animation 2007



A Case Study:

C.O.R.E. Feature Animation 2007



A Case Study:

Why was that an efficiency?

- *We increased our rendering capacity by between 300% and 360% without buying any additional hardware or software licenses.*

How did we do it and what was the cost?

- *We established a system that allowed the load balancer to do its job and to utilize the rendering resource as efficiently as possible.*
- *We moved the responsibility of managing render priorities from digital production people to a rule based system that managed priorities based on the type of job that was being submitted.*
- *The cost was in some developer time, but it was offset by savings in that we needed fewer render wranglers and artists were more productive because they weren't constantly watching their jobs on the queue.*

Productivity:

Measuring, Modeling and Predicting

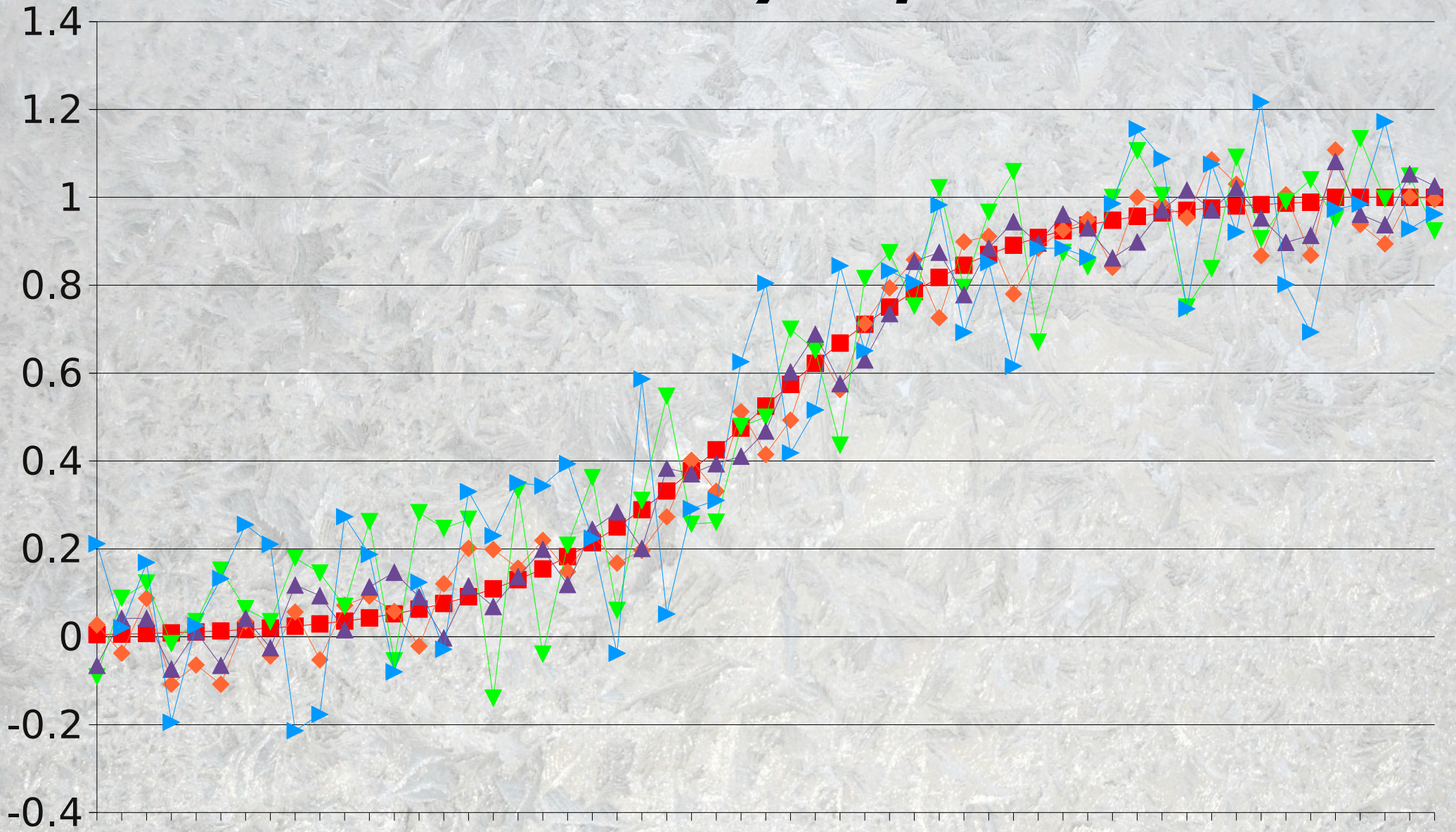
- *Initially, a heuristic method for predicting productivity is a good approach, but as you do projects, you can collect data and apply historical metrics.*
- *Product per man days, or unit days (unit in this case is a labor abstraction like a lighting team, a compositing department, etc.) are a good way to predict and track productivity, but to compare productivity technologies, money is the best metametric.*
- *Measuring and monitoring productivity is a simple matter of data collection during production.*

Common Patterns of Productivity

- *In my experience, productivity when tracked over time is always represented by a sigmoid.*

Productivity:

Hmmm... Can you prove it?



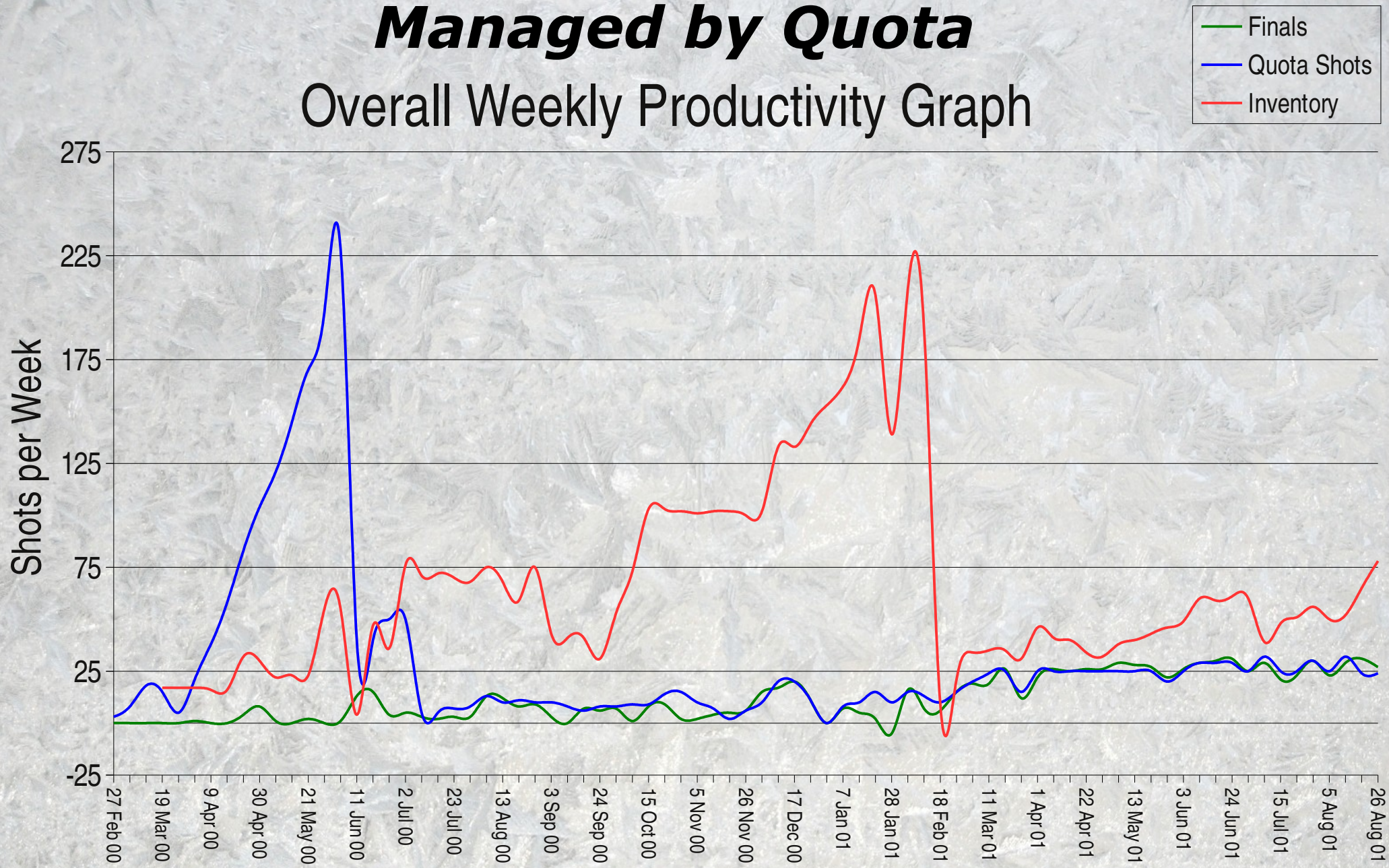
Four productions from three companies over a span of nearly ten years.

Productivity:

Another Example

Productivity:

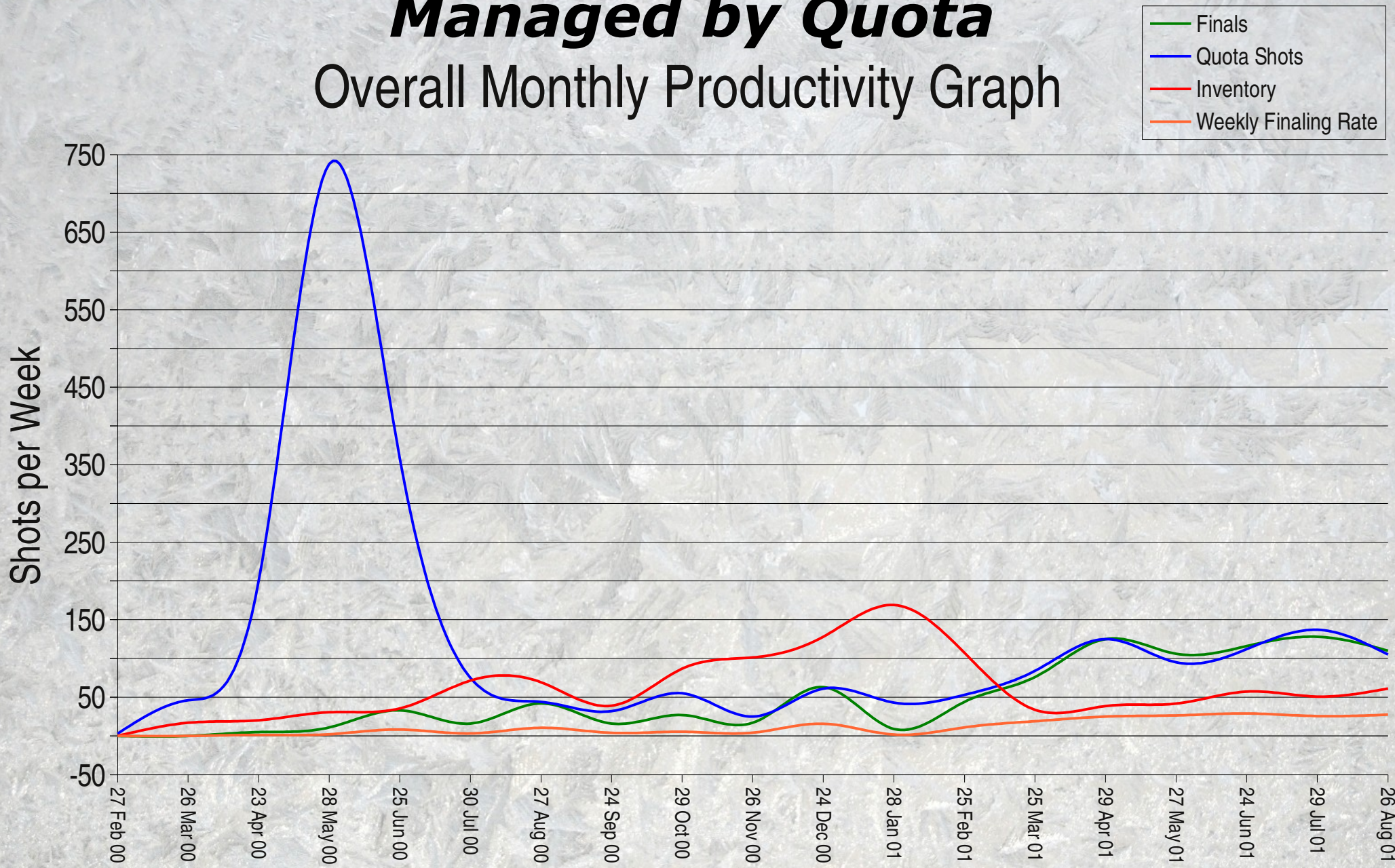
Managed by Quota



Productivity:

Managed by Quota

Overall Monthly Productivity Graph



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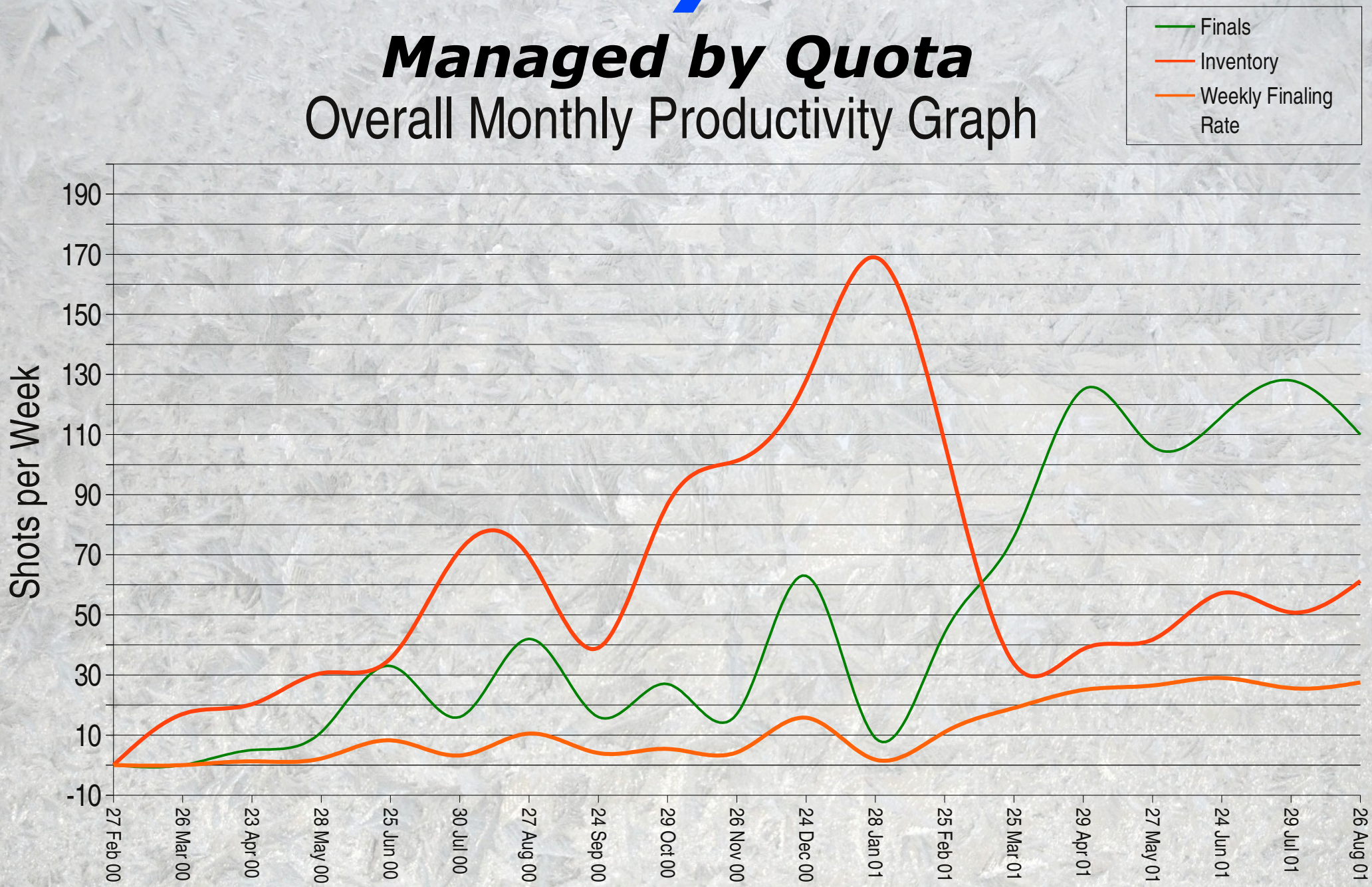


Degree of Completion

How do you incorporate degree of completion into your production management process?

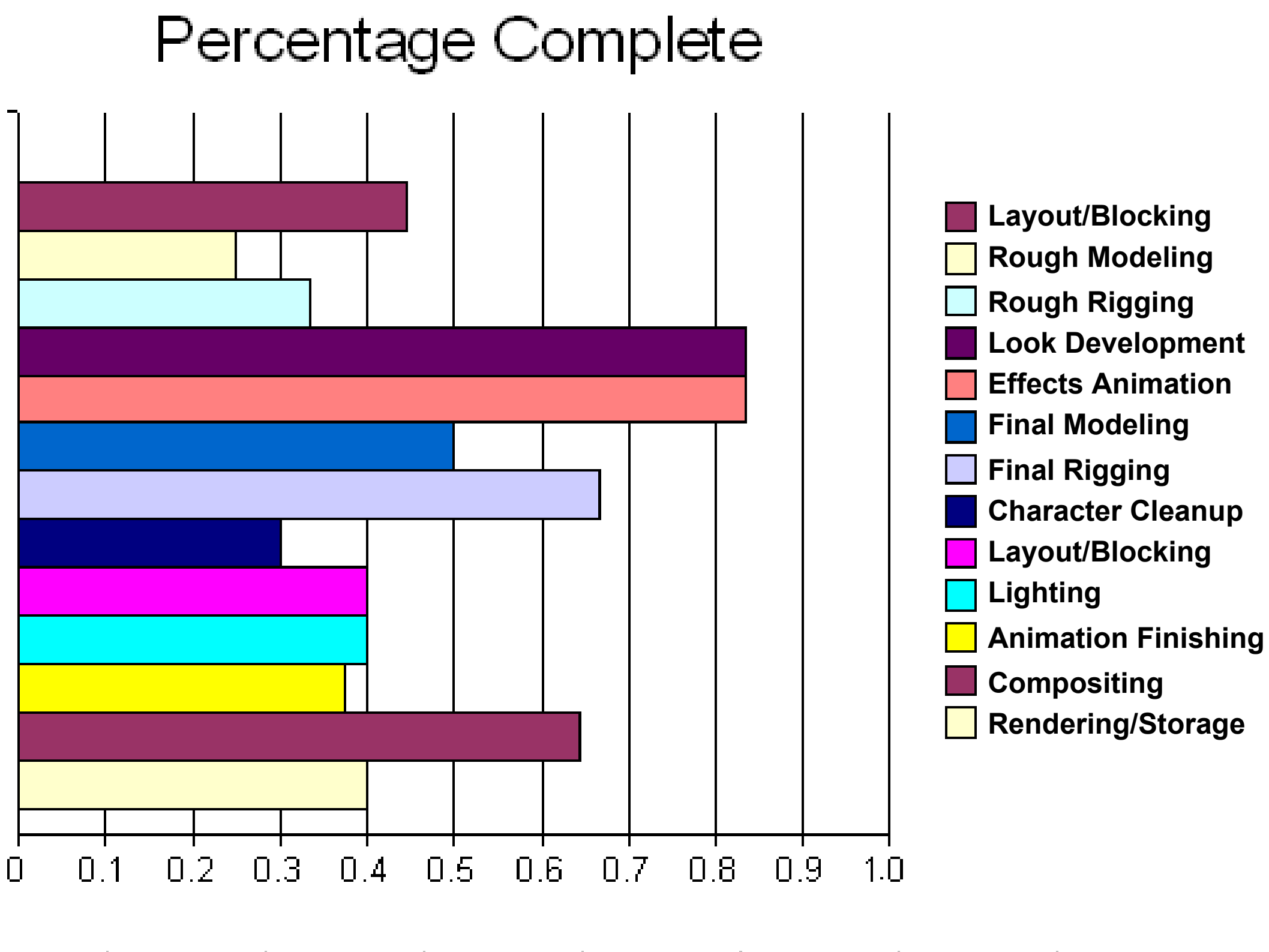
- *Each task has a degree of completion metric associated with it.*
- *Those degree of completion metrics can aggregate in any way desired to provide relevant composite view at any desired level of granularity.*
- *For any complex task, the degree of completion is the normalized, weighted sum of the degrees of completion of its constituent tasks.*

Example:

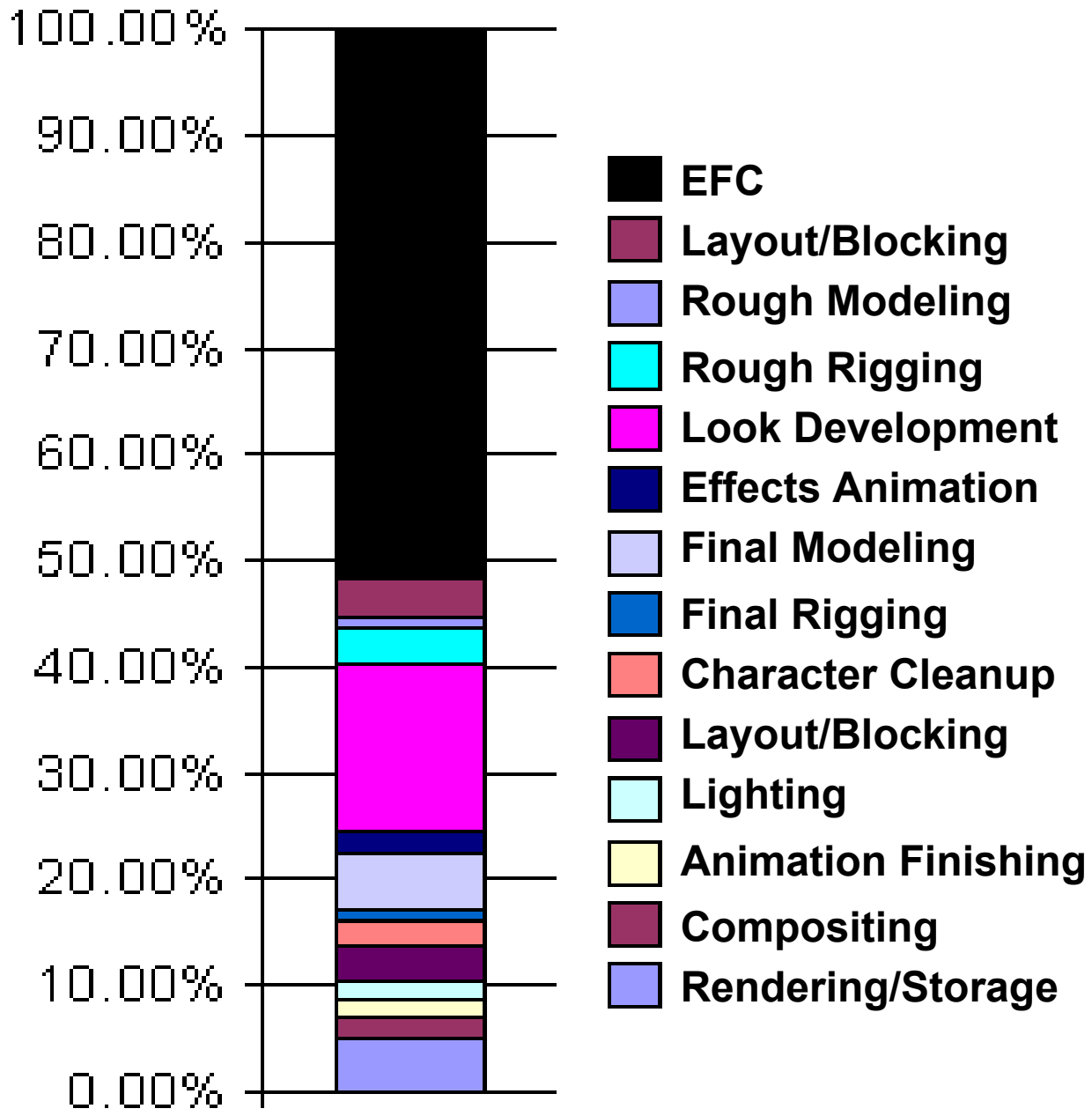
Activities	Primary Metric	Estimate	Completed	EFC	Metametric (WU)	Weighted Metametric ($)	Projected Estimate Analysis	Projected Estimate Analysis
					Percentage Complete	Total Weighted Percentage Complete	(Unweighted Units)	(Dollar Weighted)
Layout/Blocking	Man/Days	21	8	10	44.44%	4.99%	85.71%	8.97%
Rough Modeling	Man/Days	14	4	12	25.00%	2.23%	114.29%	8.91%
Rough Rigging	Man/Days	7	2	4	33.33%	1.64%	85.71%	2.46%
Look Development	Man/Days	14	10	2	83.33%	1.41%	85.71%	8.45%
Effects Animation	Man/Days	14	5	1	83.33%	3.52%	42.86%	4.57%
Final Modeling	Man/Days	10	3	3	50.00%	2.38%	60.00%	4.75%
Final Rigging	Man/Days	5	2	1	66.67%	0.85%	60.00%	2.55%
Character Cleanup	Man/Days	10	3	7	30.00%	5.34%	100.00%	7.62%
Lighting	Man/Days	5	2	3	40.00%	2.11%	100.00%	3.52%
Animation Finishing	Man/Days	21	10	15	40.00%	15.84%	119.05%	26.39%
Compositing	Man/Days	10	3	5	37.50%	3.52%	80.00%	5.63%
Render Hours	EquProc/Hours	6000	4500	2500	64.29%	0.95%	116.67%	2.67%
Online Storage	Gigabyte/Days	3000	2000	3000	40.00%	3.52%	166.67%	5.87%
					45.22%	48.28%	87.79%	92.38%

Unit Length (35mm, 24fps Footage)		
Total Footage	25	
Footage Complete($)	12.07	48.28%
Footage Complete (WU)	11.3	45.22%

This sort of analysis can be done at any level desired, e.g., element, shot, sequence, reel, show or on an activity level, i.e., Final Rigging on the above show is ~67% complete and all of this analysis can be generated automatically from data assembled through the degree of completion metrics collected as part of the normal production management process.


Percentage Complete
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Layout/Blocking
Rough Modeling
Rough Rigging
Look Development
Effects Animation
Final Modeling
Final Rigging
Character Cleanup
Layout/Blocking
Lighting
Animation Finishing
Compositing
Rendering/Storage

Normalized, Weighted Degree of Completion



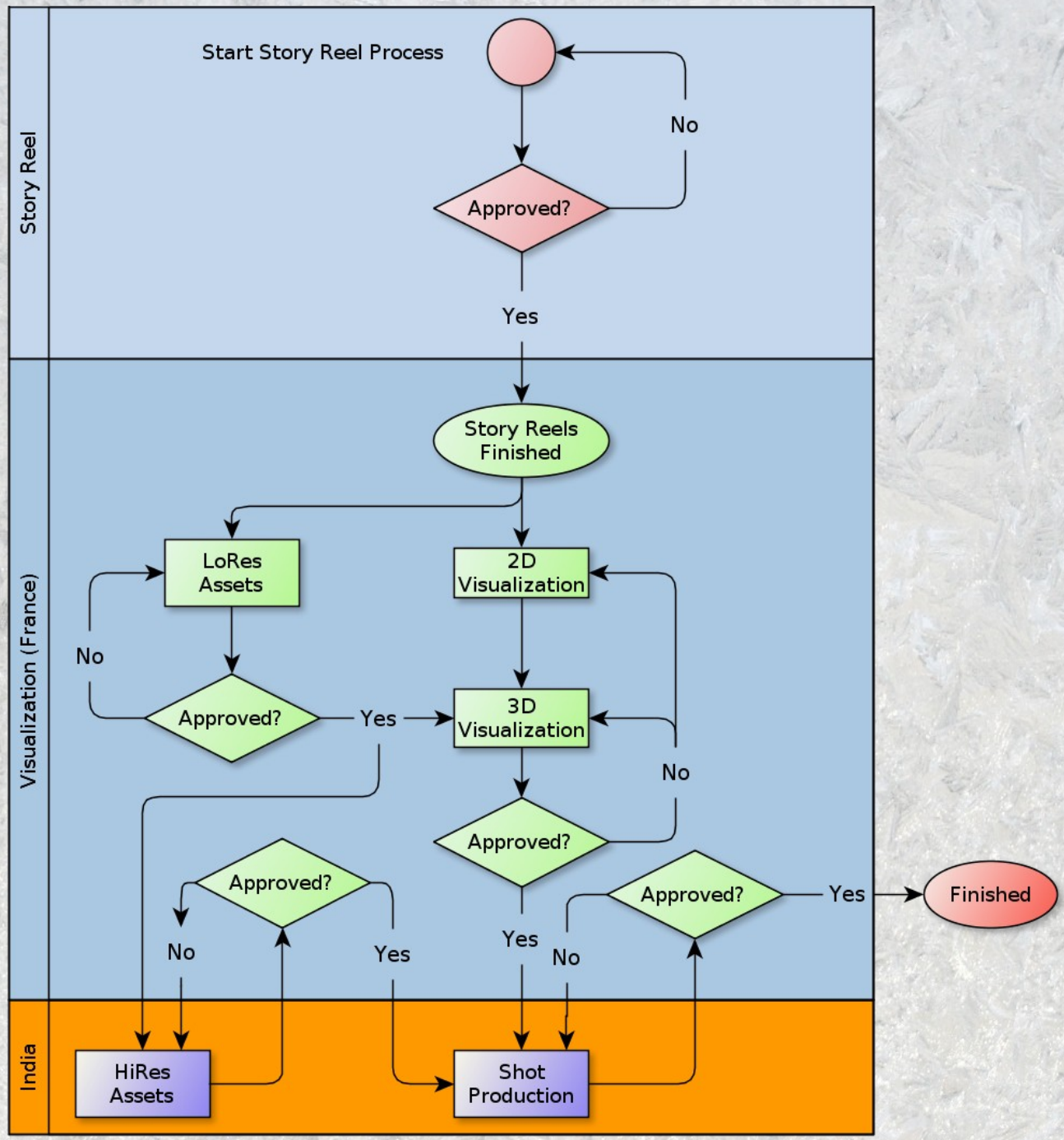
Dependency:

Workflow, Dataflow and Complexity (again)

- *The most significant opportunity for optimization of a digital production process is in data flow automation.*
- *Automation doesn't replace labor, it allows a production to leverage labor more efficiently.*
- *Dataflow models and manages the way data moves through the production process and is specific to individual shots, tools and production processes.*
- *Workflow models and manages the way work moves through the departmental structure and to individuals and has to do with departmental hand offs, approval processes and job descriptions.*
- *A digital production pipeline consists of both work flow and data flow.*

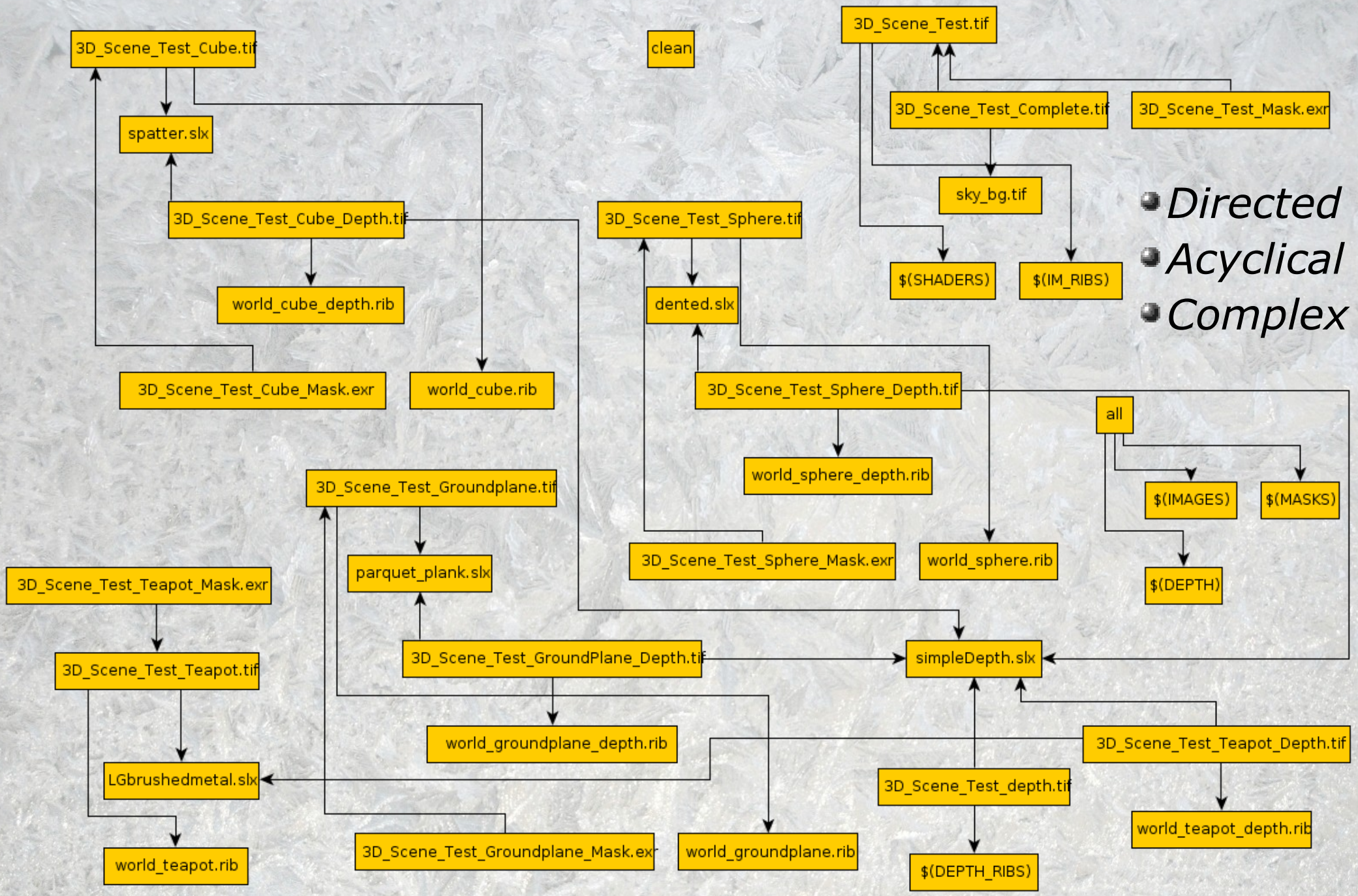
Workflow:

- *Directed*
- *Cyclical*
- *Simple*



Dataflow:

Considerably more complex than workflow!



- *Directed*
- *Acyclical*
- *Complex*

Dataflow, Datagraphs, Dependencies and Automation:

Sometimes a graphical representation isn't the best way to understand a data graph and in particular, what it does.

- *GUI's and graphical data representations begin to fail to convey meaning as data becomes arbitrarily complex.*
- *The point is to do something useful with the data, not just look at it.*
- *For any non-trivial 3D scene, the data flow and dependency relationships become very complex very quickly.*
- *Managing those dependency relationships is the key to labor savings through automation. It reduces process complexity which saves time and money.*

The Cost of Efficiency:

Efficiency implies change and implementing changes has both a cost and a value.

- *"We have a small studio. We can't afford to do things like that."*
- *You should only implement efficiencies that have a net positive effect meaning the value exceeds the cost.*
- *A little analysis can have a huge impact on the way you spend money and more importantly, the value you derive from your investments.*
- *Financial analysis isn't just for big studios. In fact, it is even more critical for small studios to insure that you are doing the right things with your limited resources.*
- *Net Present Value (NPV) and Internal Rate of Return (IRR) provide tools for making the right choices.*

The Cost of Efficiency:

Net Present Value (NPV)

- *Net Present Value is a technique for assessing the worth of an investment in terms of the time value of money expressed in terms of the current value. It is sensitive to inflation, the cost of money, all cash inflows and outflows and it is expressed in capital terms.*

- *More simply put, it is the difference between the sums of the total cost of the investment over time, minus the total cash inflow over time, discounted by the the rate of return that could be earned on an investment in the financial markets with similar risk (the discount rate).*

- *A positive NPV is good, a negative NPV is bad.*

- *It isn't as difficult as it sounds.*

The Cost of Efficiency:

Internal Rate of Return (IRR)

- *Net The discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero.*
- *Generally speaking, the higher a project's internal rate of return, the more desirable it is.*
- *IRR can be used to rank several prospective projects a company is considering. Assuming all other factors are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first.*
- *It isn't as difficult as it sounds.*

The Cost of Efficiency:

NPV vs. IRR

- *NPV is calculated in terms of currency while IRR is expressed in terms of the percentage return you can expect the capital project to return.*
- *Academic evidence suggests that the NPV Method is preferred over other methods since it calculates the total value of an investment and the IRR Method does not.*
- *The IRR Method cannot be used to evaluate projects where there are changing cash flows (e.g., an initial outflow followed by in-flows and a later out-flow).*
- *However, the IRR Method does have one significant advantage – your accountant and your financial institution will better understand the concept of returns stated in percentages.*
- *While both the NPV Method and the IRR Method can even reach similar conclusions about a single project, the use of the IRR Method can lead to the belief that a smaller project with a shorter life and earlier cash inflows, is preferable to a larger project that will generate more cash. That isn't necessarily true.*
- *Applying NPV using different discount rates will result in different recommendations. The IRR method always gives the same recommendation.*
- *Using both gives a complete picture of the investment and provides a common criteria for determining the best course of action.*

The Cost of Efficiency:

Really, it is easier than you think!

You would be crazy not to do this!

Operational Description:
A very sensible project that has a great NPV and an IRR that is in excess of the Hurdle Rate.

Discount rate	3.25%		Hurdle Rate	20.00%		

Year	2012	2013	2014	2015	2016	2017
Simple Cash Value	-$9,750.00	$5,783.33	$6,283.33	$6,283.33	$3,450.00	$3,450.00
Present value	-$8,857.97	$5,088.83	$5,354.76	$5,186.21	$2,757.96	$2,671.15

Net present value	$12,200.94		Maybe			Toons
Internal Rate of Return	49.23%					VFX
Return on Investment	100.00%					Feature
Cash Return on Investment	$15,500.00					Overhead

*The **Hurdle Rate** is the minimum rate of return on a project or investment required by an organization in order to compensate for risk, the greater the appetite for risk, the lower the hurdle rate. You might think of it as the quantification of your appetite for risk.*

Working Definitions for Pipeline, Workflow and Dataflow

- **Pipeline**

  A pipeline is a well defined, abstracted, formalized way of transforming data from one state to another through a series of managed processes.

- **Dataflow**

  Dataflow is the path data takes through a series of transformative processes in order to complete a particular task, i.e., when a pipeline is instantiated with specific data elements or "assets" that is a dataflow.

- **Workflow**

  Workflow is the system for managing, monitoring and controlling tasks and processes associated with a project.