The structuring of a VFX Pipeline

The structure, reasoning and choices

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Preface

This thesis summarizes my Bachelor’s degree in Computer Graphics at Luleå University of Technology in Skellefteå, Sweden.

I would like to take the opportunity to give a big thank you to LTU and my instructors Samuel Lundsten, Stefan Berglund, Fredrik Tall, Aron Strömgren, Arash Vahdat and Håkan Wallin who made this education possible. A special thank you to the amazing people at the anonymous studio that have given me a vast amount of new knowledge and inspiration.

Marcus Dempwolf Holm
Sammanfattning

Denna rapport kommer att gå igenom den typiska strukturen av en pipeline hos ett VFX företag. Rapporten kommer sedan att jämföra denna strukturen emot ett riktigt VFX företags egna pipeline och diskutera dom val som leder till att företag ibland gör unika förändringar av den typiska pipelinen.

Målet är att ta reda på hur en typisk VFX pipeline ser ut och få förståelse för dom val som leder till unika situationer.

• Hur ser en typisk VFX pipeline ut?
• Hur kan en implementering av en pipeline se ut?
• Vad är det som påverkar struktureringen av en pipeline?

Abstract

This thesis will go over the typical structure of a pipeline for a VFX company. The report will then compare this structure against a real VFX company’s own pipeline and discuss the choices that may push a company make unique changes to the typical pipeline structure.

The goal of this thesis is to understand how a typical VFX pipeline is structured and to gain an understanding of the choices that leads to unique situations.

• What does a typical VFX pipeline look like?
• What can a real-world example look like?
• What affects the structuring of a pipeline?
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1 INTRODUCTION

1.1 Background

“In today's film and games industry, art production is a communal enterprise. Every CG element that the audiences sees (or doesn’t realize that they see) in a theatre, and every character or environment that a player meets in a video game, is the result of the collective effort of many artists and technicians.”
- (Renee Dunlop, 2014)

The vast scale of today’s film and games industry creates a need for order and structure. An asset has to go from being a concept to becoming a finalized product, and it is important for the artists and producers to know how, this product will move through the production. The thousands up on thousands of files that have to pass through the production needs to be converted, named, and sorted. It is important for the artists to know who works on what and in what order. Therefore, it is important for VFX companies to have a structure, a pipeline. 1

1.2 Question Formulation

How is a typical VFX pipeline structured and how does it compare to a real-life example? What is there to consider when structuring a pipeline and how do these things affect the choices of real-world VFX Studios?

1.3 Purpose

The purpose of this thesis is to gain an understanding of what makes a pipeline look the way it does and what affects the structuring of such a pipeline.

- Discuss the various workflows and complications that may affect the structuring of such a pipeline.

1.4 Limitations

- This thesis will focus on the artistic areas and won’t go into detail on scriptwriting, bidding, marketing or publishing.

The focus of this thesis lies in the artistic areas. Areas such as concept, storyboard, modelling, rendering and compositing. The thesis will however, discuss the full Pipeline in a broad manner.

1 (Jeffery A. Okun, 2010)
2 Theory

2.1 Pipeline
Pipeline is a term used to describe the order and flow of a VFX production. "The term comes from computing, where it means a set of serial processes, with the output of one process being the input of the subsequent process"
- (Jeffery A. Okun, Susan Zwerman, Scott Squires, Toni Pace Carstensen, Kevin Rafferty, 2010)

"a pipeline is much the same as an assembly line, in which each worker performs their task before handing off their completed work to the next."
- (Renee Dunlop, 2014)

A pipeline informs the artists and personnel how an asset moves through production, where information is stored, who works when and on what. It is a tool that improves efficiency and maintains order.2

2.1.1 Pipeline stages
In the broad spectrum, the structure of a pipeline starts with the Pre-production, followed by the Production and ends with the Post-production, as seen in fig 2:1, fig 2:2. However, if you look closer, the post-production itself, being such a large-scale stage of the process, also consists of the same three stages.2

Figure 2:1 Structure of a typical VFX Pipeline in detail.
Andrew Whitehurst - http://www.andrew-whitehurst.net/pipeline.html

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2 Renee Dunlop (2014) "Production Pipeline Fundamentals for Film and Games" CRC Press
2.2 Implementation
When a pipeline is used in actual production however, it is rarely truly serial. Today’s technology allows us to work in parallel. We are able to go back and change an asset. This change will then be applied to the later stages of the pipeline automatically. "A production pipeline is generally not perfectly serial because real workflows usually have branches and iterative loops."
- (Jeffery A. Okun, Susan Zwerman, Scott Squires, Toni Pace Carstensen, Kevin Rafferty, 2010)

This iterative process is a gift for the producers and artists, allowing artists to work on the same asset simultaneously and allowing the producer to make changes late in the process. ³

2.3 Pre-production
Pre-production, also referred to as pre-prod, is the stage of planning. It is here that the company receive the script for the film, references and concepts. The VFX company then use the script to make a first, rough, “ballpark” budget estimate.

The VFX company then work with the client to create a storyboard, moodboard and lightboard for the film. Often hiring freelance artists for these tasks. The budget estimate is then updated, with the help of the storyboard, in order to give a more precise number.

In some cases, early production of assets also begins, assets for use in both the real world, at set, and in 3D.⁴

2.4 Production
“During the production phase, the focus of the work shifts from planning to building.”
- (Renee Dunlop, 2014)

The VFX company will send out their supervisors to on-set in order to help with the shooting of the film, giving advice to the crew which may have less experience with VFX and making sure that the artists gets what they need in order to do their work. The film-crew are responsible for recording the takes needed for the movie and the VFX supervisor will make sure that a greenscreen is used when needed and no unnecessary objects are placed in difficult spots or other things that can cause a headache for the VFX production in the next stage. During the production the company also update their budget estimate once more and start planning the post-production stage.²

2.5 Post-production
It is during the post-production stage that most of the VFX is being made. Leads and supervisors will receive the filmed and cut material, also called “offline”, and will study these in order to make the final budget estimate and bidding of the film. With the help of the offline, they will also start planning the actual work, before finally, the VFX production starts.  

2.6 Pre-production in VFX
Pre-production in VFX is also the stage of planning. It is where most of the planning, research, development of tools and risk-analysis are done. The purpose of the pre-production stage is to plan the actual production and streamline the workflow.  

“A Poorly executed pre-production tends to set the tone for everything that follows, making the next months or years of work a nightmare.”
- (Renee Dunlop, 2014)

2.7 Production in VFX
The production stage is where the artists are in full production. Things such as modelling, texturing, rigging, animation, rendering and compositing are being done.  

2.8 Post-production in VFX
“This stage is your final opportunity to make those tweaks that can rescue a failing movie or, turn a good game into a great one.”
- (Renee Dunlop, 2014)

Once you are in the post-production stage ideally, the movie should be finished, all of the assets, renders and scenes should be done.

“Strictly, post-production refers to only those tasks that are carried out once the final images have been created.”
- (Renee Dunlop, 2014)

The post-production stage is there to let you add final touches, improve the grading and perhaps even the cutting and pacing of the movie. However, this is the ideal. In reality there are often a lot of changes being made and can be a stressful part of production for artists.  

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6 VFX Producer (Wants to remain anonymous)
3.1 Data collection
This thesis was based on data collection through the following:

1. Literature and articles regarding the VFX pipeline.

2. Interviews & discussions with experienced Pipeline Managers, Software Engineers and Producers, at an anonymous VFX company. Some of which have earlier experience working at studios such as Pixar and Moving Picture Company.

3. Discussions with an experienced Senior Compositor, having worked at companies such as Industrial Light & Magic.

3.1.1 Interviewing
The interviews consisted of a mix of questions aimed at the role of the person being interviewed and general questions about pipelines. This was meant to ensure that answers were given and to draw out food for thought.

The questions were formed in a way that would help answer the three questions of this report.

• What does a typical VFX pipeline look like?

• What can a real-world example look like?

• What affects the structuring of a pipeline?

Toward the end of the interviews they turned into discussions, with the general questions as a base subject. This allowed for interesting discussions enhanced by the person’s own experiences. A way to collect not only raw data, but also thoughts and opinions.
4 Result

4.1 What does a typical VFX pipeline look like?
A typical VFX pipeline would consist of three phases.

- Pre-production
- Production
- Post-production

The Pre-production phase would include, research & development, planning, pre-visualisation, concepting and sometimes early production of assets. The pre-production is where the preparations and planning will be done.

The production phase would include, filming material, collecting references and camera data.

The Post-production phase would include the start of the special effects work.

The Pre-production of the VFX stage would also include research & development, planning, pre-visualisation and concepting. However, it will also include the start of the VFX work, things such as modelling, texturing, rigging and grooming.

The production of the VFX stage would include continued work on the pre-production. Things such as, animation, lighting, FX and compositing. It is during the production phase that ideally, most of the film should be finalized.

The post-production of the VFX stage would include final tweaking, grading and the last of the compositing. Before it is finally send to the client.

![A Typical VFX Pipeline](https://www.andrew-whitehurst.net/pipeline.html)

Figure 4:1 Overview of a typical, full production.
Andrew Whitehurst - [http://www.andrew-whitehurst.net/pipeline.html](http://www.andrew-whitehurst.net/pipeline.html)
4.2 What can a real-world example look like?
A medium sized, anonymous company’s pipeline has been visualized in fig 4:2, fig 4:3 and fig 4:4. Just as the typical pipeline, it consists of a pre-production, production and post-production. The biggest difference being the addition of more tasks and stages such as script reading, budget estimation and Motion Capture, MoCap, for short.6

Figure 4:2 Overview of an anonymous company’s full pipeline. By me – Reference, anonymous VFX Producer.6

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6 Senior Compositor (Wants to remain anonymous)

7 Software Engineer / Pipeline Manager (Wants to remain anonymous)
Figure 4:3 An anonymous company’s general pipeline.
By me – Reference, anonymous VFX Producer

Figure 4:4 An anonymous Company’s VFX pipeline.
By me – Reference, anonymous VFX Producer
4.3 What affects the structuring of a pipeline?
The most important aspects to consider when planning and structuring a pipeline for your VFX company are the following:

- Strict or flat hierarchy
- Modularity
- Flow of Information
- File structure

It is important to know whether you want a strict or flat hierarchy, and the pros and cons of these structures. It will affect the rest of the pipeline. A strict hierarchy may make the flow of information clear, everyone knows who’s above them and who’s below them, an old and sometimes efficient system. However, this can restrict the information being send to the lower part of the hierarchy. Meanwhile, a flat hierarchy would allow for lower positioned artist to give their own thoughts and insights, creating a very creative environment. This however, could cause individual additions and tweaks without receiving an “okay” from the leads or producers, which can sometimes result in an unwanted result.

The modularity of your pipeline’s software may be one of the most important aspects. The pipeline needs to be modular if you want to be competitive in quality and for survival in the long run.

The flow of information needs to be clear, who receives what information, when and how?

It is important to plan your structuring of files. Things such as naming conventions, disks, disk space, file location of disks, backups and overall structure. When working with millions of files, assets and tools, it would be difficult and time consuming to look through them all if they were named on random, when simply needing an image for compositing, or an asset for texturing.
5 Discussion
The original question posed was; How is a typical VFX pipeline structured and how does it compare to a real-life example? What is there to consider when structuring a pipeline and how do these things affect the choices of real-world VFX Studios?

This thesis has taken a look at the typical, textbook pipeline, real-world examples and the choices that lead to the differences between them.

5.1 The pipeline
The typical pipeline found described in books usually consist of a pre-production, production and post-production. It is often serially connected and lacks the flexibility and parallax workflow that is often used by VFX companies today. The typical pipeline is an ideal, an assembly line going from start to finish. It is true that this is a streamline and simple structure that simplifies the process. However, the optimal workflow of today is working in a parallax. Today's technology allows us to go back and change things, this is very favourable for both artists and directors.

Another important aspect of a pipeline is that it should work during full production, which may mean handling several projects at once. Once your assignment is finished, you don’t want to wait until the next one comes along. You want to get going immediately. Therefore, the pipeline must also allow for multiple projects simultaneously. This however, does not mean that the pipeline itself needs to treat two projects simultaneously. It means that the pipeline must allow for an artist to leave, and start on the new project, without it causing problems, whilst also allowing them to come back when needed.

5.2 Reasoning and choices affecting a pipeline

5.2.1 The flow of information
Whilst discussing the importance of a pipeline with the experienced pipeline engineers and experienced artists, a few new, unexpected aspects worth considering were revealed. Namely, the flow of information and modularity.

Some VFX companies work in a strict hierarchy system, meaning seniors and leads are amongst the few that receive information from the client directly. Whilst others work in a flat hierarchy, meaning juniors and mid-level artists are able to give suggestions, have a bigger role artistically, and therefore receive more of the same information.

One of the problems of having a strict hierarchy system is that the information getting shared gets distorted the further down the hierarchy it goes. A matter of the senior telling the lead, telling the mid, telling the junior what the client said. This can cause misinterpretations and misunderstandings.
The pros of having a flat hierarchy is that the artist may have more access to the original comments from the client and the producer, allowing every artist to have a full understanding of what the client wants. It is therefore important to have a functioning system for information sharing. Ideally, every comment from the client should be received and stored in a sorted manner, where every artist should have access.

5.2.2 Modularity
Another important aspect of a pipeline is its modularity. It is not uncommon for several VFX companies to work on the same project, or for the client to have used different file-formats than your company are used to working with. It is therefore very important for the pipeline to be flexible. It should be possible to re-use, in-house tools for multiple software, for file-formats to be converted to fit the production and for the files to be handled properly.

A VFX company usually have several in-house tools that are scripted by the companies’ own software engineers and it is important for these scripts to either be usable in multiple software or easy to translate between different programming languages.

One of the most commonly used programming languages is Python, usable in several common software such as Maya and NUKE. However, when one of the large VFX studios in London were starting to use the software, Katana, for their lighting, their artists had to learn a new programming language, namely, Lua. As Lua, and a lot of other programming languages are similar to one another, it was possible for the artists to adapt. However, it did take a few months for them to be fully comfortable using Lua. Time spend learning, that in some cases, the company may not afford. It is therefore preferable to use the same language for all of the production, if possible.

The same goes for software, it should be possible to switch software without any sort of delays. It is unwise to be anchored to one software, you should always be able to change if needed.

5.2.3 Structuring of files
The anonymous company uses something they call an “app launcher”. In the app launcher you have your shots that you are assigned to and when selecting one of your shots you can open your software from this app. Opening software this way will automatically cause the software to read and write from the correct folders, making the finding of files easier for the artists, and makes sure that the work is saved in the correct folder. This automates the process and makes sure that files are named and sorted correctly. A tool that they believe are unique to their pipeline.

How should files be handled? What if two artists are working on v.2 and one of them updates this file to v.3, should the other artist automatically get v.3 now, or should he keep working on the old file? How do you avoid these situations?
5.2.4 Choices

Tools and programming language is something that often affects the choices of software for a pipeline. A software is weighed for its functions, its accessibility and price, as well as whether it is open for scripting and programming of tools.
6 Conclusion

6.1 Pipeline
No matter whether it is purely theoretical or in the real world, a pipeline consists of the three stages, pre-production, production and post-production. Where the post-production then has its own pre-production, production and post-production for the VFX.

![Pipeline Diagram](image)

Figure 6.1 An anonymous company’s pipeline. By me – Reference, anonymous VFX Producer

6.1.1 Pre-Production
The pre-production is where the VFX company first gets involved. Rough budget estimates, storyboards and pre-visualisations gets made and the planning starts.

6.1.2 Production
During the production stage most of the film is being shot on camera and the planning of the post-production stage starts.

6.1.3 Post-Production
During the post-production most of the actual VFX work is being made. The plates are studied, planned and the heavy VFX work begins.
6.1.4 VFX Pre-Production
The VFX's pre-production consists of various preparations and early beginnings. More concepts are being made, everything is set-up, software, tools and pre-sets, and the early producing of assets begins.

6.1.5 VFX Production
During the VFX production stage the compositing starts, the animation begins, and you start creating FX, lighting the scenes and starts rendering.

6.1.6 VFX Post-Production
The VFX post-production consists mostly of compositing the last elements and mastering the shots, making sure the grading looks good and the timing and order of the shots work correctly. This mastering of shots is usually done by the client or a separate company, and not the company that created most of the VFX.

6.2 Modularity
It is very important that a pipeline is modular, in order for a company to be able to compete and improve their quality. Things are constantly evolving, the realism of movies, the technology and software. It is important to be in the loop and able to adapt to new circumstances.
7 References


2 Renee Dunlop (2014) "Production Pipeline Fundamentals for Film and Games" CRC Press


   Last accessed (22/03-18)

5 Kavon Zamanian (2016) "How an Average VFX Pipeline Works" www.premiumbeat.com
   https://www.premiumbeat.com/blog/how-an-average-vfx-pipeline-works/
   Last accessed (22/03-18)

6 VFX Producer (Wants to remain anonymous)

7 Senior Compositor (Wants to remain anonymous)

8 Software Engineer / Pipeline Manager (Wants to remain anonymous)

8 Appendices

I Figure 2:1 By Andrew Whitehurst - http://www.andrew-whitehurst.net/pipeline.html
II Figure 4:1 By Andrew Whitehurst - http://www.andrew-whitehurst.net/pipeline.html
III Figure 4:2, 4:3, 4:4 By me – Reference, anonymous VFX Producer
IV Figure 6:1, 6:2 By me – Reference, anonymous VFX Producer