OFFF Main Titles

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Univerzita Tomáše Bati ve Zlíně
Fakulta multimediálních komunikací
Ateliér Animovaná tvorba
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ZADÁNÍ BAKALÁŘSKÉ PRÁCE
(PROJEKTU, UMĚLECKÉHO DÍLA, UMĚLECKÉHO VÝKONU)

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Studijní program:	**B8209 Teorie a praxe audiovizuální tvorby**
Studijní obor:	**Animovaná tvorba**
Forma studia:	**prezenční**
Téma práce:	**1. teoretická část: Dokumentace přípravy, realizace bakalářské práce a rešerše** **2. praktická část: Titulky festivalu OFFF – 3D animovaný film**

Zásady pro vypracování:

1. teoretická část:
Cílem dokumentace přípravy je obeznámení čtenáře se všemi přípravnými a realizačními fázemi bakalářského filmu. Text odkrývá způsob a postup práce, může obsahovat také osobní postoje, a to s důrazem na potíže při realizace, hledání jejich řešení, nabyté zkušenosti. Toto se však musí vždy bezprostředně vztahovat k realizaci filmu a nesmí sklouznout k přílišné popisnosti nebo lehkovážnosti ("historkám z natáčení"). Podstatnou součástí explikace je výčet inspiračních zdrojů a nakládání s nimi. Hodnotí se jazyková úroveň textu (gramatika, stylistika), faktografický přínos a správnost odborné terminologie, také formální úprava textu. Součástí musí být technický scénář. Bakalářská práce musí obsahovat alespoň 4 knižní tituly a 3 odborné články, s nimiž autor při přípravě a realizaci filmu pracoval (teorie i technologie).
Rozsah práce a pokyny k vypracování: Povinný minimální rozsah je 20 normostran, doporučené maximum 30 normostran textu (1 normostrana = 1800 znaků) + přílohy (vypracujte výtvarné návrhy, obrázkový a pracovní technický scénář audiovizuálního díla). Odevzdat v elektronické podobě 1 ks na CD nosiči ve formátu PDF; 1 ks pevné vazby v tisknuté podobě (barevně).

2. praktická část:
Film realizujte v minimální délce 150 sekund animace bez titulků, není-li animace již v titulcích. Doporučená maximální stopáž je 300 sekund. Absolvent prokáže řemeslo animace (pohyb postavy, v prostoru, komunikace objektů, jejich stylizace, charakterová animace, timing...), stejně jako schopnost odvyprávět ucelený jednoduchý příběh epizodu s pointou. Součástí hodnocení je kromě řemesla animace i výtvarné uchopení a dramaturgická výstavba filmu. Je třeba, aby film byl odevzdán v patřičné technické kvalitě - musí dodržet předepsaná kritéria při exportu. Výsledná podoba musí být ve finálním (hotovém) tvaru.

Odevzdání 1ks videosoubor vypálený na DVD (export: velikost obrazu v bodech 1920 x 1080 FullHD 1080p, poměr stran 16:9, bitrate (kbit/s) 10,000-20,000, počet snímků za sekundu 25, poměr stran obrazového bodu pixel aspect 1:1 square, vstupní format zvuku WAV, případně MP3, parametry zvuku 48000 kHz, 24Bit, Stereo, kodek H.264).

Součástí DVD s videosouborem je také výtvarný návrh plakátu (formát 70x100cm, digitální podoba PDF příprava pro tisk, rozlišení 300 dpi ve formátu PNG nebo JPEG, režim CMYK barva), 15 snímků výtvarných návrhů, 8 snímků filmu (obojí ve stejné velikosti jako video), titulková listina. V samostatném textovém souboru napište anotaci filmu, uveďte jméno a příjmení, přesný název práce v češtině i angličtině, rok obhajoby, osobní mail, osobní web, telefon. Přiložte svou osobní fotografii v tiskovém rozlišení.

Rozsah bakalářské práce:	**viz. Zásady pro vypracování**
Rozsah příloh:	**viz. Zásady pro vypracování**
Forma zpracování bakalářské práce:	**tištěná/umělecké dílo**

Seznam odborné literatury:

BRAHA, Yael a Bill BYRNE. Creative motion graphic titling for film, video, and the web. Burlington, MA: Focal Press, 2011, 394 p. ISBN 02-408-1419-3.
WILLIAMS, Richard. The animator's survival kit. London: Faber, 2001, 342 p. ISBN 05-712-1268-9.
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OKUN, Jeffrey A a Susan ZWERMAN. The VES handbook of visual effects: industry standard VFX practices and procedures. Burlington, MA: Focal Press/Elsevier, 2010, 922 p. ISBN 02-408-1242-5.

Vedoucí bakalářské práce:	**Mgr. Lukáš Gregor, Ph.D.** Ateliér Animovaná tvorba
Datum zadání bakalářské práce:	**1. prosince 2015**
Termín odevzdání bakalářské práce:	**13. května 2016**

Ve Zlíně dne 1. prosince 2015

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doc. MgA. Jana Janíková, ArtD.
děkanka

Mgr. Lukáš Gregor, Ph.D.
vedoucí ateliéru

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BAKALÁŘSKÉ/DIPLOMOVÉ PRÁCE

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Ve Zlíně 4. 5. 2016

.....

Martin Ivo Nábělek

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ABSTRAKT

Teoretická část práce odkrývá kreativní a technické postupy, na kterých je založená výroba 3D animovaného filmu. V první řadě přináší pohled na originální koncepty, náměty, skice a další procesy před výrobou filmu. V dalších kapitolách se zaměřuje na technologii a její využití k dosažení výsledné animace, v neposlední řadě provází čtenáře mnoha fázemi produkce. Teorie je také podložená odbornou literaturou a odbornými články. Teoretická část také obsahuje moje vlastní hodnocení a objektivní analýzu klíčových rozhodnutí týkajících se výroby. Výstupem práce jsou úvodní titulky ke konferenci OFFF v Barceloně, založené na jednoduchém příběhu s Astronautem v hlavní roli.

V prvních kapitolách se práce zabývá zejména seznámením čtenáře s tématem, jelikož jde o jedno z novějších odvětví multimediálního průmyslu. V krátkosti nahlíží do historie a vzniku festivalů a konferencí zaměřených na nové a digitální média ve srovnání s historií animovaných úvodních titulků a zrodu motion grafiky. Poté přibližuje literární a vizuální inspiraci, která je klíčová pro výrobu. V další části práce popisuje vznik prvotních konceptů a nápadů. Stručně přináší charakteristiku hlavní postavy a prostředí, včetně myšlenkových procesů, ze kterých vychází. V neposlední řadě přibližuje příběh a žánr.

Součástí teoretické části je také literární připrava - scenář, technický scenář a výtvarné koncepty. Závěrem se také zabývá postupem při tvorbě animatiku a prozrazuje nově postupy, zejména využití technologie k efektivnější práci.

V druhé, praktické části práce představí nástroje použité k výrobě filmu a poté detailně popisuje proces výroby hlavní postavy, prostředí, tvorbu titulků, postprodukci, střih a v závěru také přípravu zvuku. Na výrobě postavy popisuje elementární a pokročilé postupy a autorova řešení technických a kreativních problémů které tvorbu provázejí. Zaměří se také na nové koncepty a technologické možnosti automatizace a procedurální tvorby, které jsou klíčové k dosažení nejlepších výsledků. Z pohledu grafického designu také nahlédne na práci s typografií, výběr písma, kompozici a následnou animaci titulků. V kapitole zabývající se postprodukcí provede čtenáře postupem zpracování finálních renderů, simulací optických vad a artefaktů pro maximální realismus a také odhalí praktické triky pro zlepšení celkového pracovního postupu. V závěru také stručně popíše proces práce se zvukem a tvorbu mixu.

Klíčová slova: Film, Animace, Motion Grafika, Počítačová Grafika, 3D, Úvodní Titulky, Astronaut, Vesmír

ABSTRACT

The theoretical section reveals the creative and technical approach in creation of the 3D CGI animated film. Firstly, introducing the original concepts and ideas, artworks, style frames and various elements of pre-production. In the further chapters, it focuses on the technology and its use to deliver the final animation, guiding the reader through multiple stages of the production process. The theory is also supported using various textbooks and articles. Theoretical work also contains my own assessment and objective analysis of certain decisions behind the executive. The end result is a title sequence for the OFFF festival in Barcelona, based on a simple story with an Astronaut as a main character.

Keywords: Film, Animation, Motion Graphics, CGI, 3D, Opening Titles, Astronaut, Space

I would like to thank Mgr. Lukáš Gregor Ph.D. for his amazing guidance, wise words of advice and encouragement in order to help me successfully deliver this project. I would also like to thank my mom for her kind support, which allowed me to study my desired course and pursue my dreams. I would also like to thank my close friends for their help.

I hereby declare that the print version of my Bachelor's thesis and the electronic version of my thesis deposited in the IS/STAG system are identical.

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PROLOGUE

From early childhood, I always loved watching movies or playing computer games. I loved the idea of different worlds, which back then for me felt so real, that I was easily able to dive into them. I remember seeing a documentary about dinosaurs, which was so real for that era, that I thought that they really filmed these living prehistoric creatures. I was even more amazed, when I first played a fantasy exploration adventure called Amerzone. Although the game was crazy simple in the matter of playability, the hyper realistic environments gave me sense that I was there, inside the abandoned lighthouse or unexplored jungle with never seen before animals. Combination of childhood fantasy and the CGI technology back in the days was something so illustrious that in a very early age, I definitely wanted to be able to create my own games and worlds. Sadly, I have never been good at drawing, and as I grew up I did not believe that I would be able to do so. That changed one day, when I was about 11 years old and browsing some CD's out of boredom.

Looking mostly for games I found something completely different, which absolutely changed my life. I came along a program called 3D Studio. Having a 3D and Studio in its name was enough to attract my attention, so I have installed it and started exploring. In that time, I had a very slow computer and it was too old to run any of the new games in "3D". But with the 3D studio, it was different. It was fast, and unbelievably easy to use. Intuitively I was able to create 3D primitives such as cubes, spheres and various stuff out of the box, and I fell in love with that. It seemed to give me enough power to pursue my dreams and create the worlds I always wanted.

From that point, my journey has started, and after almost 11 years later, I am still using it on a daily basis. Of course, the learning process was slow and painful, I had no internet connection back then, and I did not speak english good enough to be able to read the tutorials. Yet, I was constantly trying by trial and error, exploring every single button, having fun and enjoying the time spent creating virtual scenes. As I grew older and got access to internet I have started learning more and more. I have also started to get in touch with other people, such as the legendary czech character artist Robin Benes, or rendering master Ludvik Koutny, who both made my dream possible by helping and mentoring me, leading me to the point where I was sure, that this is what I want to do in my life to be happy. When I was 16 years old, I stood upon the probably biggest decision of my life. I had to decide for the university. Since I was not able to draw, only doing CGI, the chances

of going to an art school were close to zero. I expected that I would have to abandon my dream of becoming a 3D artist working on films and games, and I would probably go towards studying something like particle physics, which seemed at least a little bit interesting, out of all the boring economy studies and things I did not really cared about. At that time, the only schools teaching CGI were in US, light years away from the possible budget which my family could afford. Also, not going for the higher education was out of question at home.

Luckily, an opportunity emerged. Being active in the digital media communities I heard about the visual communication studies at TBU, which were pretty close to what I was doing back then - motion graphics (how the hell I started doing that is another long story). But the whole thing had a catch. I had to sacrifice a year of my life intensively learning to draw, so I would be able to apply for the course. It required me to travel 8 hours every weekend to Bratislava and back for the drawing lessons, and drawing many hours every day, holiday along with studying for graduation at gymnasium. Although (according to people around me) the chances of getting into the course were still close to none, I somehow passed the admission test and got myself to the art school. Yay!

As soon as I have started the course, I have quickly realised that It was not for me. I did not had big expectations, but it just was not challenging enough for me. I was doing commercial work for school assignments, and never got enough feedback that would help me move forward faster. Even though it was close to my desired direction, I felt like drifting away from my main goal - doing high quality artwork, crafting my own worlds and learning to think and speak visually and being constantly challenged to do better than the last time. That’s why I have decided to push myself a little bit further and applied to switch for an animation course. It was the best decision I have ever made.

All of this might imply that I like to make my life more difficult than it is necessary. And that’s also the reason why I decided to do a fully CGI piece as my bachelor's's film.

I. THEORY

1 INTRODUCTION

In this chapter, I would like to establish the basics of motion design and film titling, in order to meaningfully explain the goal of my project.

1.1 Definition of motion design

Commercials, Film title sequences, TV Identity, Installations, UI animations, branding, web content and much more. These are only few of the endless applications of motion design in modern era. But wait, isn't that called animation? The discussion regarding this matter goes on for years and the definitive description still have not been agreed upon yet. Some say that motion graphics is animation, the other side describes it as an extension to digital graphic design. In my opinion it is a hybrid of both of these fields and cannot be classified just to one or another. Motion design usually works with a lot of typography and layout, which is domain of the graphic designers, but it respects and utilizes the laws of motion, disney's animation principles, and discloses the information not only by the layout, type and shapes but also by movement.

Over the years, motion design evolved to the point where it merges various other fields aside from graphic design and animation such as photography, cinematography, installation and in certain cases a performance art, working with the latest perks of hi-tech gadgets, sensors and interactive media.

1.2 Brief history of motion design and film titles

Before the sound film was invented, we can observe that lot of the early silent movies used graphic design to convey information to the viewer which cannot been otherwise communicated.

The first examples of the title sequences can be found in silent films. These consisted of simple, non-animated title cards that informed the audience of the main film title, crew credits and talent credits. They were usually placed at the very beginning of a movie. [1]

As one of the first motion graphic titles we can consider Marcel Duchamp's Anemic Cinema. Collaborating with Man Ray, they have used various optical illusions and typography on the spinning turntable to create this unique film, greatly reflecting the era-specific style such as Surrealism, Dada and Avant Garde.

1.3 Phenomenon of film titles in context with multimedia festivals

Thanks to the spread of internet and growth of online communities in last decades, a lot of digital design themed festivals and conferences emerged. Mostly, thanks to the flash technology by adobe, which allowed people to create interactive digital content without deep programming knowledge. Since the flash was one of the biggest breakthrough in the digital technology, events like Online flash film festival (OFFF), or Flash in the can (FITC) were born. Lot of these conferences persisted to this day, and they are still growing and evolving, and even more new emerged.

Seeing that most of the digital artist back in the 2000s were experimenting with motion graphics and video art, merging these two was also a way to promote these events. We can see this especially in the first years of OFFF festival, where various studios such as Dvein and designers like DSTRUKT, Kyle Cooper and many more created opening titles resembling those we used to see in feature films, just in more experimental way. Inspiring the new generations of artists, 16 years later it slowly became a sensation in the digital design world, and a necessity of every motion design festival.

Img. 1. OFFF Barcelona, opening titles for 2011:"Year Zero"

2 SOURCES OF INSPIRATION

Inspiration is undeniably a core aspect of every creative process. Our brains are constantly perceiving the outer world, unconsciously analysing, comparing, collecting data. When a artistic work is being done, all this information is driving our intuition towards the goal we wish to accomplish. Thus, one has to experience as much as he can, to enhance his creativity.

2.1 Literature

The standard for the opening title films was already set further than just experimental visuals and nice design, thus I pursued my inspiration in various books, studying mostly fields I am generally interested in such as Philosophy, Astronomy, Science and History. One of the very inspiring books for me was Psychology and Alchemy by C.G. Jung., I really appreciated the concepts and philosophy of medieval alchemy being explained with Jung's approach to psychology. Although the book have not been used for the further concept development, It gave me a whole new point of view and totally different approach in perceiving the outer world and further work on the project. I was also looking for inspiration in various other books, to name a few such as "Death by the black hole" by Neil Degrasse Tyson, or my all time favourite, The Hitchhikers Guide To The Galaxy by Douglas Adams. In the end, a quote from the Milan Kundera's book The Unbearable Lightness Of Being, introducing Friedrich Nietzsche's concept of eternal recurrence - ad infinitum, inspired me to push the story more towards the surreal and abstract ideas, while still keeping it simple.

2.2 Visual Inspiration

Aside from the literature, my greatest inspiration source was visual. From photography and illustration to movies and games, I spent a lot of pre-production time absorbing as much as possible material to build up a sharp and precise idea of what I wanted to achieve. Many aspects of the final films were inspired by various films such as Prometheus by Ridley Scott, which inspired me in creation of the landscape aerial shots, Beyond the black Rainbow for the landing shot of the astronaut or epic 2001: A Space Odyssey by Stanley

Kubrick, just to mention a few. One of the main inspiration sources was also Interstellar, science fiction feature film by Christopher Nolan.

For my general look development, I really wanted to push the visual side of the film as much towards more cinematic style as possible, which was enhanced by using the 2K CinemaScope format with the aspect ratio of 2.39:1, later adding authentic scanned film grain and color grading with film emulation look up tables to achieve subtle color shifts characteristic for real processed film stock.

Other inspirations for the titles were obviously the main titles of the OFFF festival from recent years such as Year Zero by PostPanic, Mr. Emilton's Cabinet of Curiosities by From Form, Ash Thorp's and Anthony Scott Burn's Titles for OFFF 2014 and also opening titles from the Semi-permanent 2015 conference by Raoul Marks.

Img. 2. Scene from the movie Interstellar

3 STORY AND CHARACTER DEVELOPMENT

3.1 Concept creation

To help me cope with the writing the script and concept development, I have invited my friend Michal Chrastina to join me. We've spent hundreds of hours brainstorming and discussing various ideas. After few months, when the deadline for pre-production was getting close, we've settled on an idea of comparing light and heavy, inspired by a book by Milan Kundera. The concept was based on a comparison of an astronaut, floating lightly in the outer space and a diver, being pressed to the depths towards the extreme pressure of the ocean. However, the production drifted over my ability to execute it and after few months of intensive concept development we've decided to abandon this idea, while keeping the materials for the new film - this time much simpler and shorter. Shortly after that, we split up and I have continued the creative process on my own, starting with absolutely different approach.

3.2 Character Development

In the early pre-production, I have really wanted to work with an astronaut. Probably because of my childhood dreams of being one and obsession with space related phenomena. I was sure that he must be the main character of my film. Later on, when I found out that astronauts are starting to be a common trend in design, film, and other art fields, I have started to doubt it, whether or not shall I do the same thing. However, in the end, I have ended up with an astronaut and realised, that I should not limit myself because of the ongoing trends, everything was once said and done already so the possibility of creating something absolutely unique is almost very low.

The other reasoning behind the character of astronaut is also based on the anonymity of the main character. Since he is wearing a full space suit with UV protection golden visor equipped, we simply cannot see his face, which makes him unknown, mysterious and also its easier for audience connect with him.

The astronaut is wearing the Gemini space era suit, G4C, the one used for the first american spacewalk. The choice of this suit was based on it is design, which was more simple and cloth-like than the newer suits, which are huge and heavy. The astronaut is

basically a metaphor for an explorer, an artist or any other creative person, wandering through unknown and unexplored worlds, traveling trough space, on the journey searching for something never seen before. In the most simplified manner it resembles the curiosity of a human being. My intention was to portray the astronaut not as a professional staff of nasa, or a macho conqueror of alien planets, but in more human, regular way.

3.3 Environment design

Being inspired by the Akira Kurosawa approach to cinematography, especially by his use of natural elements such as rain, fog and wind, building strong emotional connections between the picture and the audience I decided to start the film inside of the rainy thunderstorm. To keep the simplicity, the film is set in the middle of the desert, which may, or may not be alien, making it more a mysterious.

Most references for the environment came from the volcanic deserts of Lanzarote, various Iceland places, and also from the Death Valley. The environment mostly consists of arid rocky mountains and sand with gravel, however to avoid the classic sci-fi cliche such as hot deserts of mars, I have decided to lean towards the overcast sky and desaturated sandy ground.

3.4 Story

The story of the film went through many iterations, some made it more complex, but later, realising the overall running time of the film and limitations of my abilities I was forced to strip the story down to the very basics, creating a linear narrative which can be easily understood without going too much into deeper philosophical concepts, difficult to communicate in such short timespan. Another aspect that I had to deal with was keeping the motions and action clean because the audience will have to focus not only the animation but also on the titles.

The story itself ended up being very simple journey, without any impactful plot twist nor multiple storylines.

3.5 Genre

It’s hard to define exact genre for the film. In the very basic matter, it is still a title sequence, but if we look closer to the various aspects, we can find elements of science fiction, mystery, documentary genre in the film. Main representation of the science fiction, where the film fits the most is definitely the main character - astronaut, and the ending scene in space. This feeling is also emphasized by the choice of music, which is has a specific atmosphere with futuristic electronic sounds. The establishing shots are made more in the documentary style, calm closeups and aerial shots, with subtle, shaking camera. On the other hand, the opening scene with the beaming of an astronaut down to the planet, and the ending with the loss of gravity are supposed to be more of a mysterious elements.

4 PRE-PRODUCTION

4.1 Screenplay

Film is based on the very simple screenplay. From my personal experience in this type of work, spending too much on the script does not provide satisfying outcome, especially since the main goal of the film is more in the visual part rather than narrative. To start the production, I have built a primitive screenplay so I can divide the film into the multiple smaller parts, but I tried to invest less time writing and more time working on the further visual materials, which ended up being a wise decision.

4.2 Storyboard and styleframes

As written above, the written part might be well suited for production where a lot of information is communicated and also a spoken narration or dialogue occurs. In my case I put most of my focus on the development of visuals, with a clear goal of achieving theatrical cinematography and realism.

Most of the work was based on the hand drawn storyboards, which helped me to brainstorm various ideas and later come up with the key shots. Only disadvantage of this process was difficulty of translation the sketches into the CGI, and therefore most of the storyboard was made as a styleframes, not showing all the shots, but the most important scenes that set the style of the rest.

The reason why the sketches did not worked so well is obviously my lack of drawing skills. On the other hand, I spend quite a lot of time practicing CGI, especially challenging myself to be able to quickly outline basic scenes which can serve as a concept, or “sketch” and also serve as a starting point to the scene assembly, and layout. Basic problem with the drawn storyboards lays in the misalignments between the creative layouts and compositions on the paper, and physically plausible camera and perspective composition in the world units 3D virtual space of the computer program. What worked on the paper was usually too hard to achieve when I was working with real world sized figure and a lens I would probably use in the live action shooting scenario. Because of this, I focused all my efforts on creating quick and best looking styleframes, that served as a reference of what is possible and will look good in the film. Also, I was able to try various

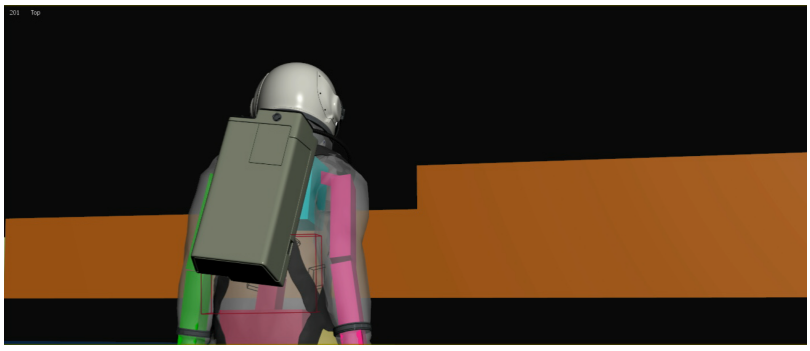
look development versions really early, resulting in a huge speedup of later production.

4.3 Previz

Another key element of the pre-production was previz, which was usually done first by recording the viewport, and later rendering very fast low quality frames of the final animation, which allowed me to see how the lighting, camera and composition works together with colour and focus. This turned out as the best workflow element, since I was quickly (in the matter of minutes) able to see how the final will look. Noise free render usually took from few hours to the few days rendering. This also prevented the production of multiple re-renderings of the shots due to some errors like wrong movement or incorrect lighting.

The was also directly loaded to the NLE (non-linear editing) software, where I was able to check the shots in context with each other and with the final material. In the beginning I was using Adobe Premiere for this, but later I switched to Davinci Resolve, since it had much better performance and compatibility. Due to the ability of loading raw renders in EXR format, I could quickly check the finished rendering to confirm and approve it for further work without any compositing needed.

This also kept the working process much more live and modular, so I could try out various versions and combine final shots, raw renders, previz, styleframes and storyboard together, having an overall view of the whole project.



Img. 3. Previz of the CGI shot

II. PROJECT

5 TECHNOLOGY IN PRODUCTION

CGI stands for computer-generated imagery, or just simply computer graphics. We can describe computer graphics as a *"...cross-disciplinary field in which physics, mathematics, human perception, human-computer interaction, engineering, graphics design and art all play important roles. We use physics to model light and to perform simulations for animation. We use mathematics to describe shape. Human perceptual abilities determine our allocation of resources - we don't want to spend time rendering things that will not be noticed. We use engineering in optimizing the allocation of bandwitdth, memory, and processor time. Graphic design and art cobine with human-computer interaction to make the computer-to-huma direction of communication most effective."[2]*

5.1 Tools

The amount of applications used in production of my film is enormous, but considering that as a generalist I was doing all the work from creative, through 3D creation, animation, motion capture, rendering, compositing, editing, pre-grading, finishing, sound and mastering, it is not as hardcore as it might seem.

For the pre-production a number of tools was used. For reference management, I have used Adobe Bridge, for writing I have used multiple tools such as free app Simple Note (which allowed me to share my text between multiple devices, such as laptop, desktop and my phone). Most of the written material was done using Google Docs and for the brainstorming and mindmapping I have used free version of Mind Mup online mindmap creator.

In the actual production, the main workhorse of the project was obviously Autodesk 3D Studio Max, loaded with plugins as Grow FX (not used in the end due to the script changes), Forest Pack for scattering and generating ground surfaces, Thinkbox Frost for meshing the particles out of Pflow, used for the shots with dripping and flowing water. Debris Maker script for procedural generation of some assets, and Corona Renderer as the main rendering engine. For character design and creation I have used Pixologic Zbrush R7. For character mesh retopology I have used TopoGun. Character was animated using iPi Motion Capture software. Landscapes for the environment were procedurally generated in

World Machine. The texturing process was handled using Photoshop and Substance Designer, while using Bitmap2material for preparation of repetitive textures for procedural environment workflow. Some of the texture were also captured using photogrammetry in Agisoft Photoscan and source elements for creation of procedural stormy sky were done in FumeFx. The final compositing was done in After Effects CC, and further post-production and editing in Davinci Resolve. Finally the sound was done and mixed in Steinberg Cubase. To finish the list, the network rendering was handled using Autodesk Backburner and for dailies and exr reviews I have use open source DJV player.

5.2 Workflow

"To be successfull in this field, you need to become a problem solver with good observation skills and a desire to create things. You never stop learning in this field. You face new challenges with every new project, many of which require innovative solutions that you must discover on your own. If you get to a point where you stop seeing these challenges as lessons that help build your ever-growing skills set, it is probably a sign that you've lost your passion for the medium and it may be time to explore other career options." [3]

As already mentioned in the Theoretical section, my workflow was mostly based on constant reviewing and updating the film as a whole, keeping things consistent and in context.

Since I will be describing certain parts of my workflow in the further chapters, I would rather point out some interesting details which made my life easier and helped me through the production.

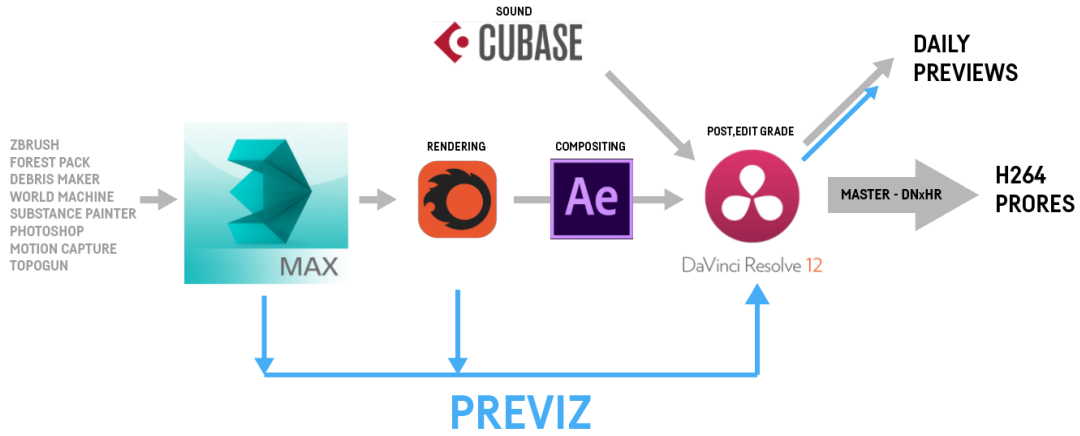
Main aspect was project management, where spreadsheets with thumbnails, shot IDs, camera info and frame lengths were stored. Using this method allowed me to track the progress and see where I need to iterate more and what as already done.

The modeling workflow was mostly procedural, except the character, which was build from scratch while using a low quality free 3d model as a transparent reference to keep the proportions. To make the whole process more modular, I was trying to utilize Xref referencing in 3Ds max, but I was not successful with it and had to abandon it. With Xref, I wanted to reference the astronaut from the clean scene with the rigged character only to the

shot scene, and in case I have decided to change something on him, i wouldn't have to go through all the scenes, since the model or rig will update itself everywhere.

Another tough challenge was transferring the camera data from 3D Studio Max to after effects. To achieve this I have used various scripts, depending on the camera rig and type of animation I was using. FBX export worked great in the most of the times.

Finally, I found a very useful workflow for remote grading, utilizing After effects, due to the familiar tools, while keeping everything inside DaVinci Resolve. Using this approach I was able to delegate the grading to my friend Petr in Prague. Basically, I would pre-grade all the shots in davinci, to match the colours and luminance of each shot, so they will look consistent. Next step was exporting stills and creating a simple After Effects file with them. Then I would transfer the file to my colleague, who did the grading in the separate adjustment layer. After that, using a plugin called LUT buddy, I was able to extract the grading information to the 3D LUT - Look Up Table, and load it into DaVinci Resolve as a new node. Thanks to this approach I was able to continue editing and working on the project without need for exporting the graded footage and re-conforming it again into the timeline.



Img 4. Workflow

6 CHARACTER DESIGN AND DEVELOPMENT

In this chapter, I will focus on the general approach to character design and development. I will go through each stage of the process, explaining the principles of digital character creation using a set of dedicated tools.

6.1 References

Creating a CGI character is one of the most challenging parts in the film production. Every step has to be planned ahead to ensure that the whole process is fast and frictionless. Major changes in the design might cause trouble and can lead to repetition of the whole process from scratch, losing crucial amount of time which might be needed in the other steps of the pipeline. Although major industry leading studios have developed pipelines that allow such changes, small teams and especially solo artist do not have enough resources to manage similar workflow and therefore they need to focus on each step, keeping in mind that there might be no possibility of return whatsoever.

To make sure that the character is going to look as good as possible is necessary to gather enough photo-references. This also applies in production of unreal and stylised characters. Usually their design inspiration comes from different sources such as nature, animals or cultural symbols. With enough photographs, such library can be used for painting custom concepts, or for direct production - modeling, texturing, material development, etc.

For this project, I have used Adobe Bridge for reference management. Thanks to its minimal interface and easy access and browsing I was able to keep my focus and inspiration without complicated and redundant actions that would break the creative flow. To gather the references online, I have used services like Flickr, Google Images and NASA archives.

We can divide the reference into “Muse references” and “Usable references”. Muse references are mostly pictures which we gather in order to build up the inspiration library and they are usually containing one or more essences based on the mind mapping process. On the other hand, the usable reference purpose is to be used as a direct asset in either Digital Matte Painting, Texture creation or in the compositing.

6.2 Modeling

3D modeling is a process of creating virtual objects in three-dimensional space. These objects are constructed of the most basic units - vertices (sg. vertex). Vertex is simply speaking a point with position in X, Y and Z axis. Vertex usually does not carry any further information itself except ID number and vertex colour. When two or more vertices are connected with line, an edge is created.The position of an edge in 3D space is defined by the position of its vertices marking the start and the end. Two or three edges connected together can create a polygon. In professional language, polygon is often called face, surface, triangle or quad. Polygons, apart from vertices have multiple attributes. They carry most of the information which define the final 3D model such as normal vector (vector which is perpendicular to the surface of polygon), texture and UVW mapping data. Object made from multiple polygons is called mesh. Advanced modeling is usually done by modeling objects from primitives such as Box, Sphere, Cylinder and many others, or manually by extruding edges from a two-dimensional plane. No exact modeling workflow is defined as standard, it is purely an individual style how anyone build 3D assets.

Modeled mesh can be further deformed by various modifiers, ranging from simple bends and twists to noise, displacement and many more. Modifiers are also useful in procedural and organic modeling, creating randomisation and variation, or organic deformations to add virtually tactile textures and structures on the surface of the object. To create details, one has to subdivide the mesh, multiplying the amount of polygons. More subdivision levels means more details, but also heavier data size and greater computing requirements. Although the modern computers are extremely powerful in comparison with systems used to develop first CGI in late 60's, they still cannot handle huge amounts of objects and polygons effectively. This problem is also caused by ignorance of big software development companies like Autodesk, refusing to rewrite the code of their applications to efficiently utilize latest hardware.

Polygon modeling is not the only approach when it comes to 3D modeling. There are also other techniques such as voxel modeling or nurbs and more, but these are not used in standard production due to heavy limitations and incompatibility with common workflows. Voxels for example are pixels with volume (Volumetric pixel) therefore models can be constructed from millions of voxels like atoms in real world. Yet, modern consumer technology is still not powerful enough to handle the amount of data required.

NURBS are on the other hand mostly used in engineering and architecture, since the surfaces created by this method are purely mathematical and therefore limited to only non-organic modeling.

Latest years of technology development brought also a whole new concept of digital asset creation for public. It is called 3D scanning. Even though the industry leading studios used LIDAR scanning already 20 years ago, the technology is still extremely expensive, and not available for the public sector. This have been changed by widespread of affordable DSLR cameras and photogrammetry software, which can transform multiple photographs into detailed mesh, producing also perfect textures as a bonus. Only complication is, that the raw mesh is not usable directly for the production and needs extensive cleanup and simplification for further work.

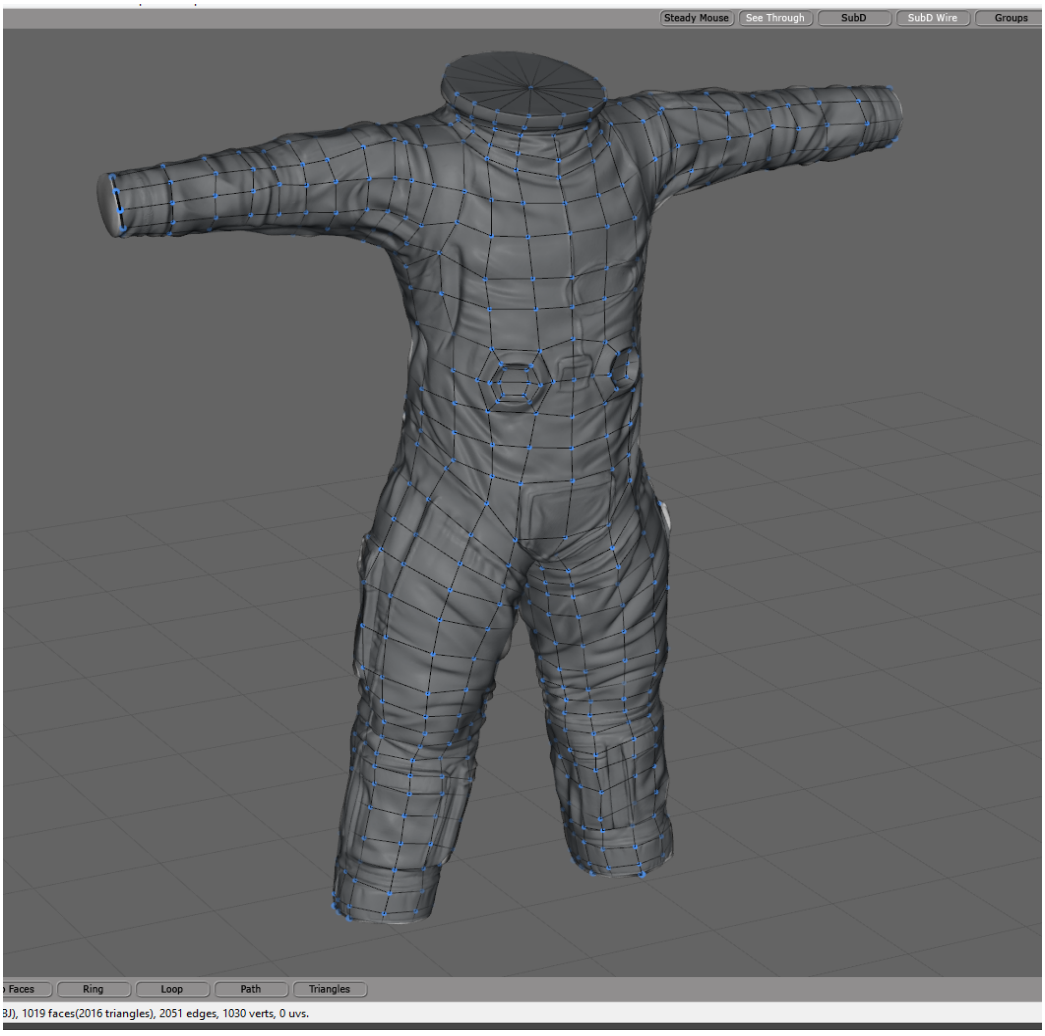
In my case, I went with standard polygon modeling. Using Pixologic Zbrush I have built a base mesh from NASA reference model publicly accessible from their archive. This simplified the early modeling work while keeping the correct proportions and volume. Using the tool called “Dynamesh” I was able to deform the suit to my requirements, with automatic mesh generation and even distribution of subdivided polygons.

Starting from a very primitive model, I have tried to roughly block out most of the features. Next, I had subdivided the mesh and further modeled the character and its features. Repeating this step multiple times I was able to achieve strong detail and believably realistic model of an astronaut.

The final model in Zbrush with all the details is of course not production ready. It’s polygon heavy, with multiple billions of points and gigabytes in size. Such model needs retopology, a process that creates a low poly model with correct edge flow required for rigging, animation and UV data for high-poly detail projection and map creation.

For retopology, I have used software called TopoGun. The process itself is very simple and relaxing. First, the high quality mesh is loaded to the application. Next, the low polygonal mesh is drawn over the original one. Application takes care of conforming the new low polygon mesh onto the original surface. Edge flow is an expression for the direction of the edges in mesh, defining the right polygon positions and sizes. Correct edge flow means clean and animation ready model with no unnecessary facs, ready for the further production steps.

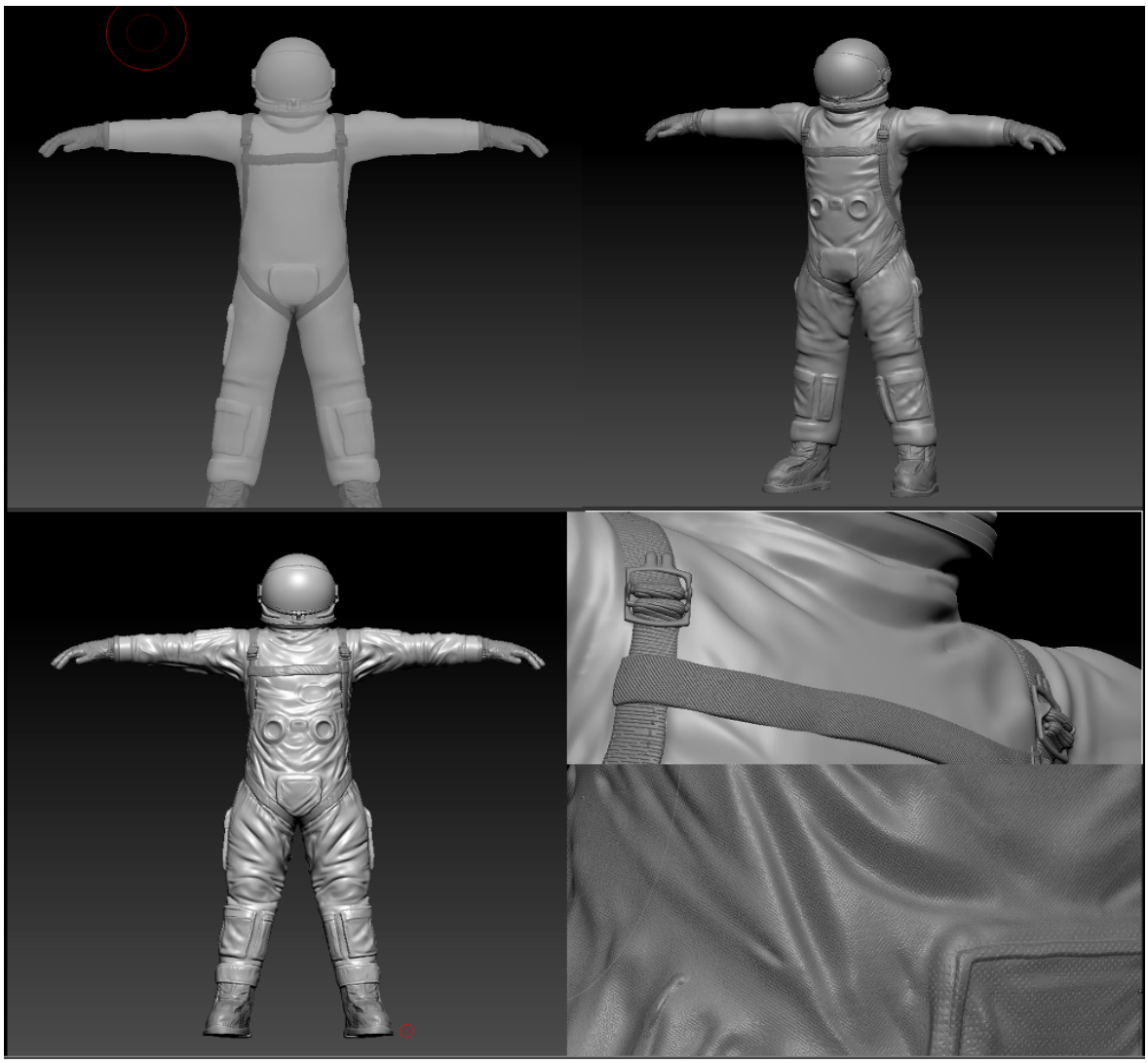
The retopologized mesh is then transferred into the application called 3D Coat, which has very easy UV mapping tools. UV mapping is a process of cutting the mesh so it can be flattened to 2D surface and used for texture painting. We can compare this process to the paper model building, where you cut out the paper parts which are then bent and glued together to create three-dimensional paper model.



Img. 5. Retopology in TopoGun

With UV mapping and correct topology, it is time to generate normal, displacement and ambient occlusion maps from Zbrush. This process generates a texture which compares the difference between the low poly and original high poly mesh and outputs the information into the 32-bit floating point map. With the same approach it also creates normal map, containing information of the surface features in form of RGB texture which represents normals for local XYZ space of each polygon. Ambient occlusion map is not

necessary, but it helps in the next stage of texture creation. It is calculated upon proximity and angle of model faces, creating often called “dirt” effect, with black in the concave parts and white on the flat surfaces.



Img. 6. Modeling process of Astronaut

When all these maps with the low poly model are exported, the character modeling part is done. Displacement and normal map will be used to add the original detail back to the model in the rendering stage, while keeping the workflow fast and professional. When the final shots are rendered, the low poly model will be subdivided in the background, and deformed using the displacement map generated in Zbrush. Normal map will enhance smallest of details, emulating the light conditions of the scene on the material level, without need for such extreme subdivision. It will be also used for the “level of detail” objects (often called LODs) further away from camera, where no actual subdivision is needed.

Img. 7. Models of Gloves and boots from the Astronaut character

6.3 Rigging

In this chapter, I will briefly explain the process behind rigging and skinning which is necessary for further animation of the character. Rigging means literally adding bones and manipulators to the characters. We can compare this to the puppetry. To make a puppet move, you need set of strings and joints inside of it. In 3D, a helper objects are created and positioned inside of the object. Using hierarchy and parenting, we attach these objects one to another, creating virtual joints affecting each other. In high-end production, rigging is mostly technical and exceptionally complex process, utilizing various programming languages such as MAXScript, MEL, or Python to add broader functionality to the rig and also help animators in the later stages to easily achieve lifelike results without need for coding or technical background.

Rigging itself is not enough to prepare the model for animation. Despite the fact that we can move the bones and animate them, it does not affect the character model in any way. The process of attaching a 3D model to the skeleton - rig, is called skinning. In this step, one has to define deformation zones for each bone and its adjacent part of mesh. This is still very complicated and long process, because it is usually required to manually attach vertices to the bones and set their weights. Weights define how much is a single vertex affected by each of multiple bones. Incorrect weights will cause glitches and anomalies when the position of the bones will change, degrading the final animation.

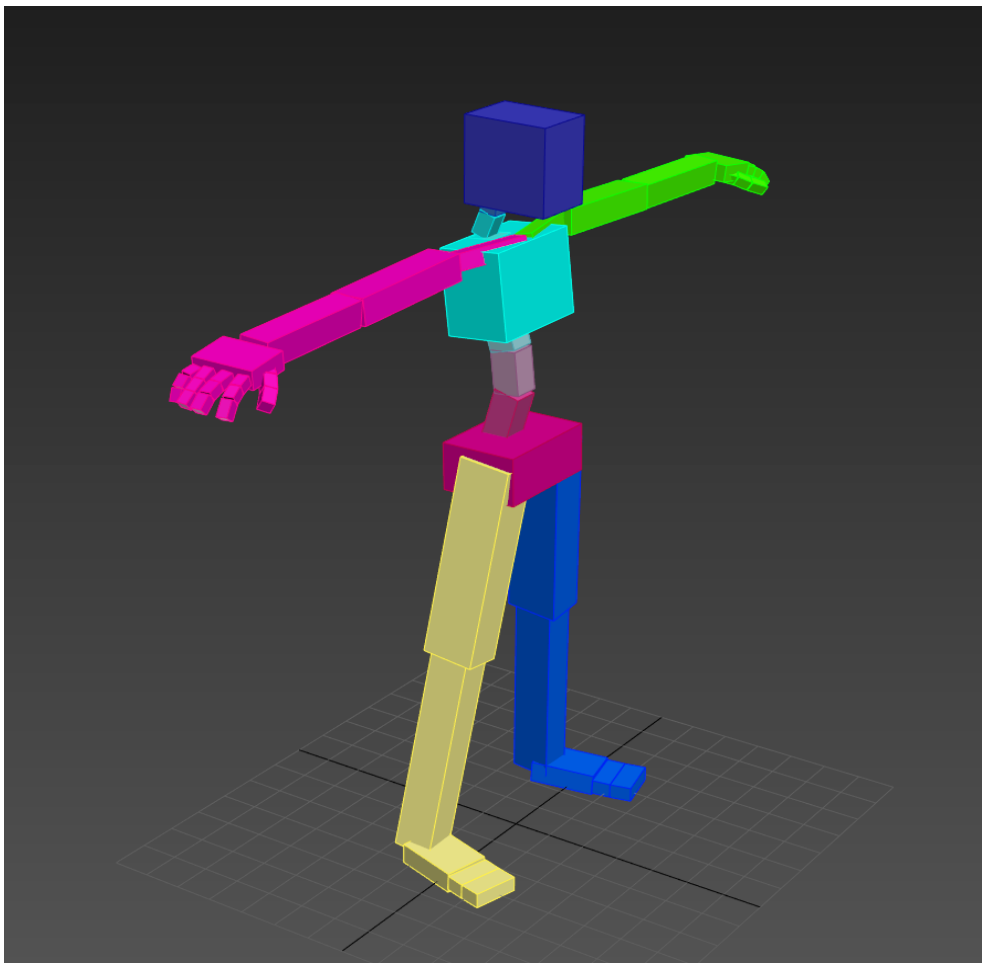
To rig and skin the astronaut's character, firstly I have decided to use a Auto-rig and Auto-skin plugins which made the whole process relatively easy. I was able to quickly set up a temporary skeleton, then adjust the bones without breaking the constraints and after I was happy with the rig, the plugin has created helpers for animation. Skinning process was also heavily simplified, and allowed me to achieve acceptable results pretty much quickly.

After a month of production time and plenty of broken rigs later, I have realised that there are too much issues with this rig and therefore I was forced to optimize it. Just in time, a new service pack for 3Ds Max arrived, fixing the CAT rig technology, which is a built in solution for rigging in Max, but for a long time was impossible to use because of the bugs and instability. Thankfully, I was able to learn quickly how to create new rig using CAT and that basically saved my project.

CAT rig is technology originally developed by Softimage XSI developers, made for easy rig creation in 3Ds MAX for game design and animation. Sadly, for many years it was unusable due to the heavy bugs and problems. In the latest version of the 3Ds MAX the CAT rig seems finally working just fine, and thanks to the new voxel skinning technology, I was able to rig and skin the character in much faster way and more efficiently. The new rig also made the whole scene lighter, resulted in faster parsing and rendering times and also CAT technology simplified the process of working with motion capture data, allowing me to combine multiple mocap data layers together, which was not possible with the previous solution.

After the skinning is done, character is ready for animation using the prepared helpers and controllers. These helper objects are important for animation, because the animator can focus on the movement and does not have to constantly go through the hierarchy to select parts of the body to work with.

In high end production, studios often add one more step in between skinning and rigging. To create ultimate realism, they add muscular system with physically simulated dynamics. This allows them to achieve subtle deformations on skin, caused not only by bones but also by muscle movement. It is commonly used in films, especially on CGI animals and humans. One of the biggest innovators of this technique, pushing it further more towards perfection is Weta Digital studio.



Img. 8. CAT Rig of the Astronaut

The CAT rig have also basic tools that would allow me to do this, and it would result in much better animation for sure. But since I had to recreate the rig and skin again I have lost too much time in this part and I have decided to rather not play with fire and move on with the production.

6.4 Textures

"The challenge of replicating tactility and movement has always been a preoccupation for digital designers. In an attempt to mimic the tangible qualities of the real world, surface pattern and texture are artificially applied to digital forms, creating trompe l'oeil illusions

of realness."[4]

As previously mentioned, the ambient occlusion maps generated in Zbrush are excellent start for a texturing work. They provide us with plenty of information about the model and also can be used for masking dirt, decals and wear for more realistic textures.

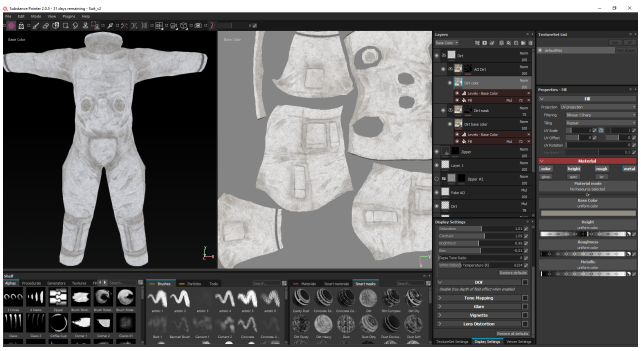
Applications such as Quixel or NdO or Substance Painter, allows users to generate a lot of nice textures procedurally, making it effective for less important objects or game models.

In the case of astronaut, the first version textures were mostly based on the ambient occlusion map combined with fabric patterns and mainly different albedo regions of the suit, such as palm of the gloves.

Later in the project development, a new version of procedural texturing software come out, and having an evaluation license available, I have decided that having a more complex textures would definitely push the astronaut towards better realism. On the textures, I have collaborated with a friend, who took care of most of the texturing process.

Using substance painter, we were able to create complete sets of textures for each part, such as gloves, boots and suit, simulating wear, adding fabric detail and enhancing the model features. The software was fortunately optimized for working with physically based rendering workflow, and even more, it was able to output maps directly for the Corona renderer.

For the generic environment textures, also another piece of software was used. Using the Bitmap2Material I was able to easily generate additional maps from a single photography reference. It also helped me to create seamless tileable textures for general use in the environment creation.

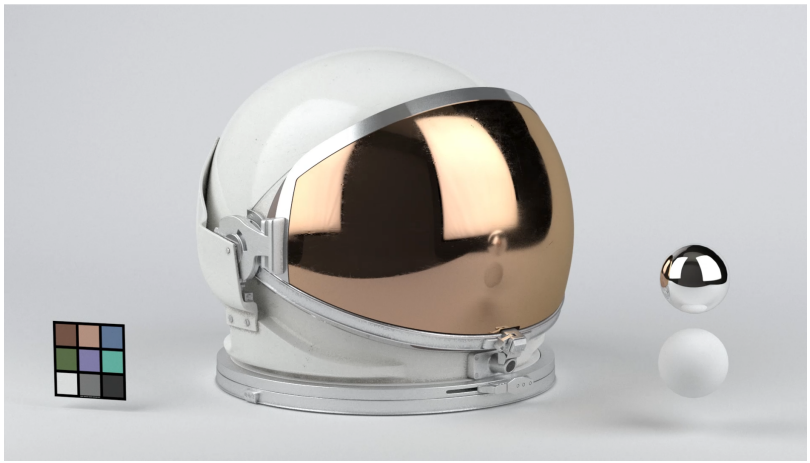


Img 9. Substance Painter, process of texturing

6.5 Shaders and Materials

A while ago, before the GI and advanced ray tracing was introduced to the rendering, people usually had to fake most of the materials and shaders to achieve near realistic results. This process was complicated and rarely delivered realistic outputs. Today, with powerful computers we can easily simulate the reality, based on physics of light transportation, producing photorealism intuitively and quickly. Using latest unbiased rendering plugins, we can correctly simulate effects such as Subsurface Scattering (SSS), translucency, or GGX microfacet surface shading, delivering physically plausible results - making it harder and harder to distinguish renders and real photographs. Having all this technology on the click of a mouse sounds exciting, but one has to keep in mind that without proper skills, it will still result in long rendering times, which will make a small project without big renderfarm impossible to render.

Thanks to my few year study of physically based rendering, long-time Vray and Corona experience and help from my friend Ludvík, I was able to create simple, but good enough looking materials for the astronaut. Displacement and bump maps were used directly from Zbrush. To emphasize the wrinkles of the suit, I have additionally sculpted a tileable normal map in Zbrush, which was used in combination with the original suit normal map.

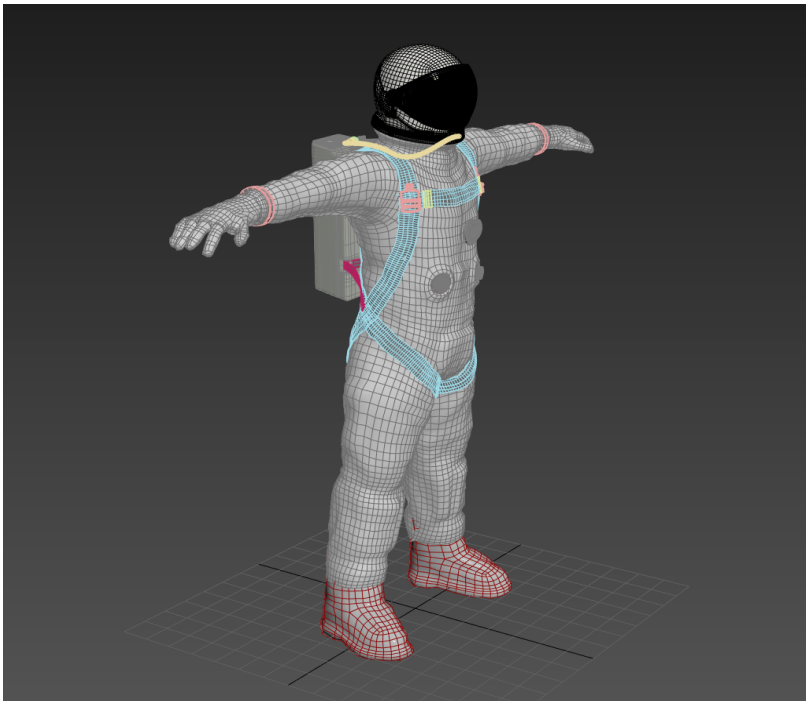


Img. 10. Helmet look development

Based on the fact that all the non-metallic materials are translucent, to achieve softer lighting on the suit I had to apply the simplified SSS on it, creating smoother shadows, and adding another bit of realism. For the helmet, I have done some research on the NASA archives, to find out that materials commonly used were usually anodized aluminium, stainless steel and polycarbonate plastic. To simulate the attributes of these materials, it was necessary to set a correct albedo intensity, Fresnel Index of Refraction, and reflection glossiness. Subtle textures were added to vary the diffuse and reflection and add a little bit of wear to the materials.

6.6 Assembly

Since the final character is divided into multiple parts, making it easier to adjust them, make changes or remove if necessary, it needs to be assembled together. To achieve at least little bit of non-destructive workflow in my character development, I did the rigging and skinning part with a low polygonal base mesh of human body, allowing me to later attach the suit and other parts or exchange them if needed. After putting all models together, I had to create special constraints for the vents on the suit, so they won't deform when character bends. Then I made sure that all displacement values are correct and produce exactly the same result as the original high-poly mesh.



Img. 11. Assembled model of an Astronaut

6.7 Rendering

"Computer graphics can be rendered in many different visual styles. Some projects require photorealism (images that can be mistaken for a photograph), while other projects are stylized in different ways or designed to create more illustrated or cartoon-like looks. Whether or not the visual style you adopt is photorealistic, your lighting still needs to be believable to the audience." [5]

This part of the whole pipeline is one of the most crucial for the look of the film. Choice of the right rendering engine, making the settings optimized and proper workflow implementation sets the style of the production and also the speed. There are multiple rendering engines used in the industry. I will briefly introduce them, compare them and finally I will describe my choice and workflow using Corona Renderer. We can divide the renderers to the two categories. Unbiased and biased. Simply speaking, the biased rendering uses certain algorithm to simplify and speedup the rendering process at the price of the realism and precision. Basically it rounds the values so the calculations are faster, and uses additional methods to produce faster and less noisy results.

The other type of rendering is unbiased. This type is more precise, the results are far more realistic, speaking of details and nuances which are mostly hardly noticeably but, relevant when trying to achieve photorealistic look. Most of the common renderers are hybrid, giving people ability to use biased solution when necessary and go more “brute force” when its possible.

The most common rendering engines out there are Arnold, Renderman Vray, Mental Ray, Corona Renderer and Octane. All of these can deliver amazing results, but the ratio between so called “artist time” (i.e the time required to set up the renderer for desired output) and render time (time for rendering a single frame) is what matters the most. Arnold is a high end production standard used in VFX industry for many years, from hollywood blockbusters to advertising. It’s not the fastest one, but it has a huge toolset, great features, produce stunning results and is sadly not supported for 3Ds Max. If it was, It would be probably my rendering engine of choice. Renderman is also not for max, and it is similar grade as Arnold. Mental ray is a rendering engine, among many others bundled with 3DsMax, for a solid two decades it was a workhorse for archviz and vfx work, but in the last few years, it got outperformed by Vray and soon with Corona. Although its native 3Ds Max rendering solution, the settings are complex, complicated and absolutely not

intuitive. Requiring a lot of artist time spent on setting it up and my no experience with it, I was not going to use it as well. The last three common rendering engines are more like a golden standard for freelancers and 3ds Max users. Vray is probably the best one, but also a very expensive. It is a great solution for vfx and photorealistic rendering. Octane is on the other hand a GPU renderer, utilising the graphics card instead of CPU. One of the biggest problems of GPU rendering today is a memory limitation of the consumer grade graphics card. Although the most expensive cards can offer around 12Gb of memory, they cost astronomical prices and to have faster rendering one needs more than a one.

Logically, Vray could be the best solution for my project, but considering my experience with Corona renderer, I have decided to learn things the hard way.

Corona renderer is fairly new rendering engine. It's made by a czech developers, and I have a long history with it. It started as a bachelor's project of my friend, and by the years it has grown to become a serious competition for the Vray and other mainstream renderers. From early development of it, I was helping my friend Ondra who programmed it during his studies, with various branding tasks as soon as he (and many other people) realised that it has really big potential. The friendship with them and also my curiosity of exploring the limits of Corona Renderer drove me towards the decision of creating my film with it. The renderer is still evolving and does not have all the features as his competition, but regarding the fast render time, and so little artist time needed on setting it up, I was convinced to continue with it. I was crazy enough to even work with unstable daily builds, beta testing the features that were far from ready for production. Even though the decision to use unfinished and unstable software in the most crucial part of the workflow was absolutely insane, I don’t regret it at all. Sometimes the limitations help push the creativity far more than expected, and drive us ways we might never go on our own.

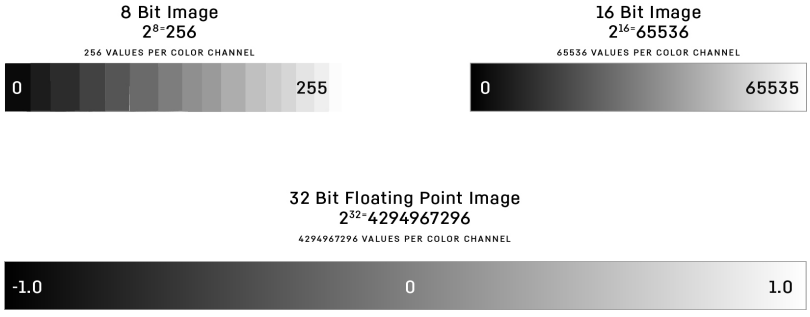
6.8 Network Rendering

I think it is important to mention the rendering process of the film in general. During the production, tens of thousands of frames were rendered, in previz, tests, and also final renders, multiplied by many iterations. But how was it possible? Of course, with average render time of 15 minutes per frame on a single machine this would be physically impossible. To reduce the load of my workstation, I have built two additional render nodes equipped with Intel i7 six-core CPUs, which were utilized 24/7 to deliver clean frames and

also quickly preview the animation in context of lighting and materials, giving me more space to push the visual side of the project. A total of six computers were used for the rendering during nights, and 3-4 during the day, based on the usage of the workstations of my peers. For the render farm management I have used Autodesk Backburner, which is incorporated with the 3ds Max. Distributed rendering was also a huge help in the pre-production process. When distributed rendering is used, the scene is rendering on a single workstation, but the complex calculations are sent to the render slaves to speed up the rendering of a single frame tremendously.

6.9 Image Output

Another aspect of the rendering is the output format. There are tens of different image formats around these days, but each of them has different use. For 3D rendering, an EXR format is almost a golden standard. Some people are used to render to TIFF or TGA sequences, but for me the EXR is definitive choice. Open EXR is a lossless image format capable of containing multiple channels from render elements. It is designed to save the data in 32 bit floating point format. 32 bit floating point means that a single pixel of each channell can contain a range of 2^{32} = 4294967296 values of information which is far bigger than 255 values per channel in 8 bits, or 0-65536 in 16 bit. In 32 bit depth, I am able to manipulate the image in extreme ways without any quality loss. Basically it can go anywhere from negative values (used in displacement maps) to extremely high numbers, giving the image a truly unlimited dynamic range. This allowed me to brighten the shadows without introducing unwanted noise and artifacts to the image, or reduce the highlights to keep maximum detail in extremely lit areas and reflections.



Img. 12. 8bit, 16bit and 32bit values

7 ANIMATION

Computer animation is process of setting virtual 3D or 2D models into motion. Nowadays, when computers are part of our daily life, we look for ways to automate everything that does not need conscious execution. We use the computers where a lot of repetitive task are getting done and animation is one of these fields. Thanks to the the computers, we don't have to draw each frame manually, to get 6, 12 or sometimes 25 frames for one second of animation. Computers are making the animation process easier, giving us great space for creativity and simplifying the rest. Without this power we would never be able to produce CGI on such level as we can see in some recent movies. They does not only helps us creating interpolation between keyframes, simulating dynamics of the movement and calculating interactions. They can simulate motion simply by learning trial and error. Computer models learning to walk and run are nothing new out there.

7.1 Standard keyframe animation

Standard keyframe animation is a process of animating CGI characters or any other models by hand, using keyframes. Each object in 3D has three basic parameters - position, rotation and scale. Depending on the type of object, it can have many more parameters based on modifiers, materials, dynamics, etc.. We can animate all of these parameters, by creating different values for each frame. This does not mean every single frame tough. 3D Animation software is capable of real time interpolation - calculating the values between two keyframes. That means, if you want to move an object from position A to position B in 100 frames, you will set a keyframe for position A on frame 0, then move the time slider to the frame 100, move the object to position B and add a second keyframe. Software will automatically calculate the in between values of the position, so when you playback the animation, the object will move smoothly. There are multiple types of interpolation. Linear, Bezier, Auto Bezier and Continuous Bezier. Each can be individually assigned to every keyframe, also separately for in and out. This allows us to add basic dynamics to the animation. Since we can see the change in real time, we can tweak the interpolation curves to desired result, such as easy in, easy out, bounce, overshoot and many more.

Even though this sounds extremely easy, and in the end it is, the real trouble starts when you have a complex object or a character made from many elements. One does not

simply animate such thing easily. Not only there are 3 animation track for each position axis, you also need a very good orientation skills to not get lost between hundreds and thousands of animation curves which need to be precisely coordinated to achieve smooth and aesthetic motion.

Usual workflow using this technique starts with blocking. The main poses of the character are set, without any interpolation. Purpose of this is to set the rough timing and composition of the character in space, drafting the interactions and important actions in the scene. After the blocking is done, usually two phases of animation follow. First phase is focused more on interpolation between the actions and postures, making sure that everything moves correctly. After the interpolation is done, the details are added such as finger movement, facial animation and interactions of the character's surrounding. In this phase the camera movement is animated as well. Phase two is determined to clean up the whole animation, add dynamics and tweak the subtle nuances of movement to add necessary character or realism to the animation.

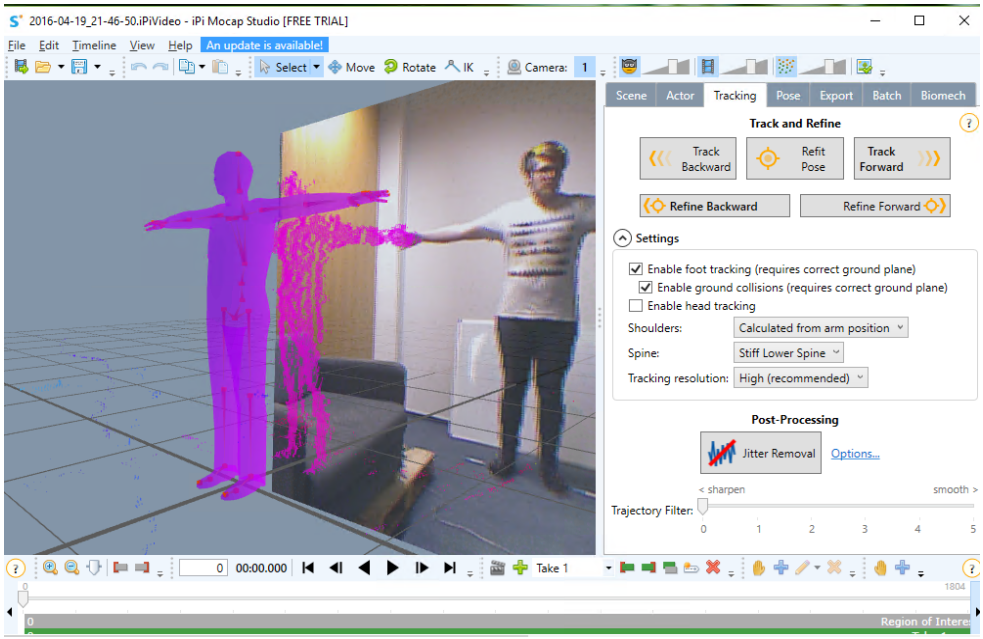
7.2 Motion Capture

These days, the demand on fast turnaround of huge amount of 3D character animation is rapidly rising, and therefore keyframe animation might not be so efficient. Especially in film industry where the life-like animation is necessity, the motion capture technology finds its use. There are multiple types of motion capture techniques and technologies used in the industry, but I won't be going in such detail. Basically there are three common types of motion capture. Standard motion capture utilizes infrared cameras from different positions and point markers placed on a special black suit. With the latest software, the big companies are able to track the actors in real time and map the motion on the virtual character to see the expected result immediately. Another type is using gyroscopic suits which does not require markers, but are not as precise as the standard studio motion capture. The sensors are able to detect rotations and changes of position and then transfer the data to the computer in real time. The third type is markerless motion capture, which is the least precise one, but extremely affordable, even for students like me. Using a kinect sensor, psEye, or another high frame rate or depth capable cameras, one is able to record the motion of an actor and then using specialised software such as iPi Mocap Studio which calculates the human motion based on the recorded data. This technique is also the slowest,

because it cannot work in real time, and usually there are many other factors which make it extremely difficult to use on higher-end production. The workflow using markerless mocap also requires a lot of manual cleanup and post processing.

In my project, I have used markerless mocap, combined with a stock mocap data to achieve required realism. Originally in the pre-production I was planning to utilize the multiple ps Eye camera rig for the bigger movement space mocap, but due to the time and budget difficulties, I had to abandon the idea and stick with the old Kinect v1 sensor, which done pretty wonderful work, being a single unit with really crappy depth perception.

After I have recorded movements, I have had to fit the pre-made skeleton to the depth data from kinect. After that I let the software to calculate the first pass of motion, checking for any issues that will result in recording the sequence again. After a successful first pass, I would set the jitter reduction and let the software cleanup the noise from the motion. In the end I would run last pass for total motion cleanup inside iPi mocap and export the BVH animation file which I would later convert to BIP, which can be loaded to my CAT rig.



Img. 13. Motion Capture with Kinect

7.3 Virtual Camera Animation

Photography is my hobby and to become better CG artist, It's crucial for me to study optics and imaging technology, so I can reproduce it later in the virtual environment. Picking the right lens as I would choose in real life cinematography, setting the correct aperture for physically plausible depth of field were the most important steps in creating a virtual camera. Next step was animation. Although the camera movements were mostly dolly, or subtle panning, I have used multiple noise controllers on the camera and it is target to resemble natural movement, with non-perfect framing making the final animation look more alive. To enhance the overall atmosphere, i would add even more camera shake to emphasize and dramatize a particular shot.

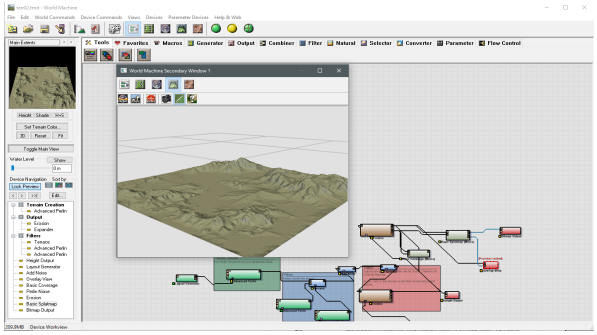
8 ENVIRONMENT DESIGN AND DEVELOPMENT

8.1 Procedural Modeling

To create realistic large scale environment, one needs to use more complex approach than manual modeling. In this case, I have used a procedural terrain generation software called World Machine. This node base landscape generator allows to combine multiple mathematical noise creating algorithms and also simulates various natural phenomena such as erosion, which enhances the believability of the landscape.

The process starts with drafting the main landscape. By drawing different geometric elements on the map, you can define where the mountains should be, where the ground is supposed to occur, etc.. After that we connect the node to the Advanced Perlin noise generator, which produces multiple levels of variable scale noise, from small hills to great mountains. From this point using a set of other nodes such as terracing we add the variation into the landscape. In the end the erosion is added, simulating decades of weather and water damage on the landscape, producing little canyons and sharp mountain tops. After I was happy with the landscape design, i've added some more levels of detail and finally, generated a procedural splat map - RGB mask for further shading in 3D Studio Max. The splatmap was based on the erosion modifier, therefore I was easily able to create different materials for rocks, eroded ground and the desert sand. The landscape was exported in the form of a displacement map in 16 bit TIFF image.

Procedural modeling of the terrain is the only plausible process to achieve realistic and believable environments, in combination with the user controlled masks and deformation, it is a very powerful tool, used widely in game and film industry, creating fictional settings or recreating a real world places with aid from online terrain data.



Img. 14. Worldmachine

8.2 Procedural Textures and Shaders

The texturing process of landscape was also done procedurally. To start with, I have divided the landscape into two separate materials, masked by the Splat Map from World Machine, where different color channels represented various materials.

First, I have focused on the sand material, since it was used in many closeups, but also in aerial shots. Combining multiple tileable textures of high resolution sand and mixing them using the noise map in 3D s Max allowed me to create enough variation so the tiling was almost invisible. I have also utilized the terrain splat map to vary the colour of the sand in the places where it was in contact with the rock, making it even more consistent.

Next step was to create rock shader. To achieve good looking large scale rocks, I had to reach for good starting texture first. For this part, I have used Bitmap2Material software to generate a depth and normal map from flat photograph of cliffs, which I later used to fake large surface deformation on the mountains. Then I added a little bit of Ambient Occlusion to the material, simulating dirt and enhancing the plasticity.

Using one landscape, only cropping the portions for close up scenes allowed me to keep consistency in the project, and faster workflow, since I kept the single material all the time and it worked in all conditions.

8.3 Lighting

Lighting of the environments and scenes was done using combination of HDRI images by Illuminated Tools and Corona Sun object. In most cases the HDRI was enough, since the collection I was using is perfectly calibrated and Corona can easily utilize it to produce extremely realistic lighting.

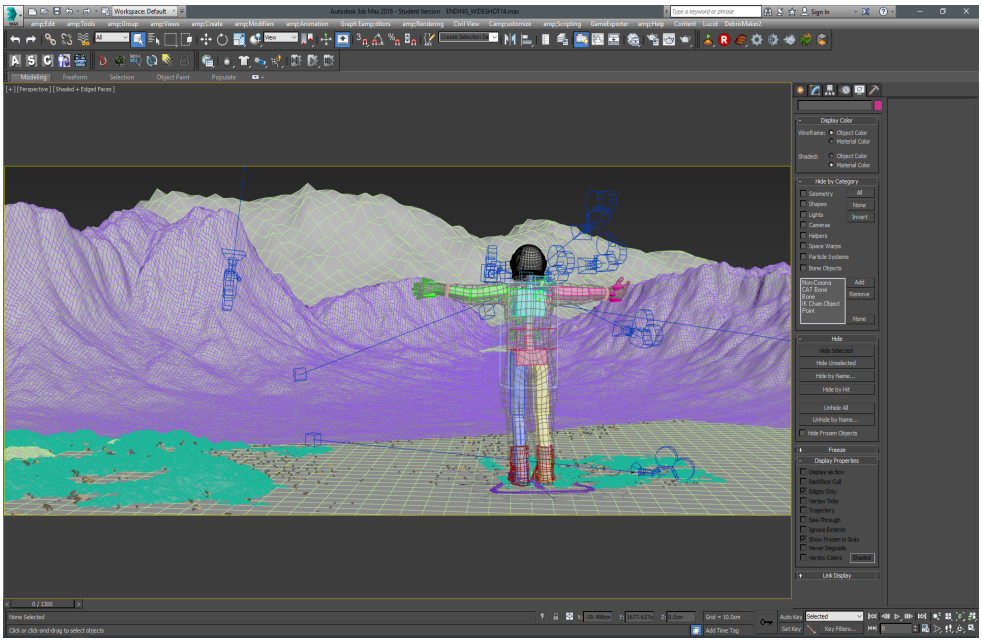
To light the night storm shots, I had to create a volumetric cloud object on top of the whole landscape, to further guide the light to create desired look and atmosphere. For lightning, a group of animated Corona Light was placed inside the volumetric objects with randomly animated intensity bumps. The lightning was needed to be done in the rendering and could not been faked in compositing, because of the sharp shadows produced.

8.4 Scene Assembly

For faster orientation in the scene, parts of the landscape which was originally 10x10km large were often hidden, allowing me to subdivide the visible part even more to add necessary details.

After landscape, I would add the animated character to the scene, then set up the lighting and do few previz tests. Continually, I would add some more objects such as rocks and gravel in the areas of focus using Forest Pack. The gravel and rocks were generated in Debris Maker and further modified, textured and exported to the library from where I would import them if needed.

For the volumetric lighting I have created simple boxes and assigned them with Corona Volume Mtl to simulate the fog.



Img. 15. Assembled scene in 3D studio Max

9 MOTION GRAPHICS AND TITLE DESIGN

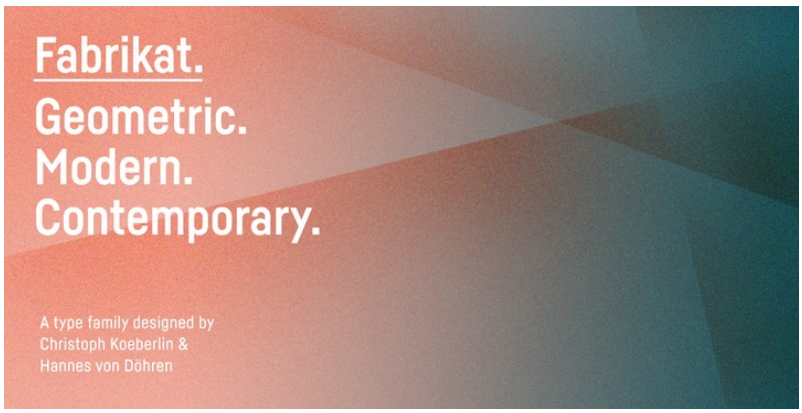
9.1 Typography

"Choosing an appropriate typeface depends on a number of factors, some of them seemingly contradictory: the conent of the text, the tone of the authot's voice, the period in which the text ws written and the intended audience." [6]

As I previously stated in the beginning of this work, I wanted to focus on the cinematography, and therefore my idea of the design for the titles was more about the readable subtle typography.

As Li Yu states in his Graduate thesis: "*The film title is meant to establish the context and set the tone of the movie, where typefaces could be a powerful assistant toward this goal due to their second-level communication abilities and special expressive qualities. Type contains impassioned rhetoric; the magic is hidden under the appearance of each typeface. Thus choosing a suitable font is the primary task a designer needs to accomplish when assessing a project." [7]*

To achieve best readability and emphasize the emotional message from the film, I was considering multiple typefaces such as Cinetype by Grilli Type, Brandon Grotesque by HVD Fonts, and Fabrikat from the same type foundry. After many tests I have decide for Fabrikat which turned out to deliver the right message I wanted to communicate.



Img. 16. Fabrikat font promo image

9.2 Layout and Grid

To achieve consistent layout, I have developed a grid which defined the proportions of typeface, and also defined the size for the frames used around the text. The frames created visually interesting contrast with the typography, making the text easily readable in short time.

9.3 Animation

To balance the amount of motion in each shot, I was using animation only for specific purposes. For shot with important information I have used static titles, so they won't chaotically distract the attention of the audience, while for the long establishing shots with mostly static or aerial camera I have animated the per-character appearance of the title, and emerging frame as well.

10 COMPOSITING, EDITING AND POST - PRODUCTION

Compositing is the process of combining multiple CGI elements, such as backgrounds, raw renders usually with live action footage. In the case of full CG film the compositing process often describes the enhancement of the rendered imagery, adding backgrounds, correcting colours and primary colour grading. Another important aspect of compositing is also emulation of various optics deformations. In my film the compositing process mostly revolved around combining the raw renders with sky, adding a little bit of optical artifacts and enhancing the contrast and colours to create consistent visual output.

10.1 Emulation of optical artifacts and defects

The laws of physics in real world result in various optical phenomena observed in photography and cinematography. These are mostly barrel distortion, chromatic aberration, flares and bloom. Chromatic aberration is a common defect, which is caused by wave-like nature of light. From the elementary physics, we know that the speed of light is lower in volumes with higher density than vacuum. Since the colour spectrum of light has different speeds already for each colour, it results in different wavelength for certain colours, creating red-blue or most commonly yellow-purple fringing around the high contrast edge areas of the picture.

Another element of the real world optics simulation is creation of lens flares. This is a common issue caused by the reflection of the light between the lens elements. Even though every lens create flares, the type and characteristics of the lens flare define the quality of the lens. The flares on the high-end prime lenses are very clean and soft, compared with ugly distracting lens flares of cheap optics. To achieve realism, I was trying to replicate flares of the higher level lenses while keeping little bit of artifacts to make it more believable.

10.2 Enhancing Photorealism

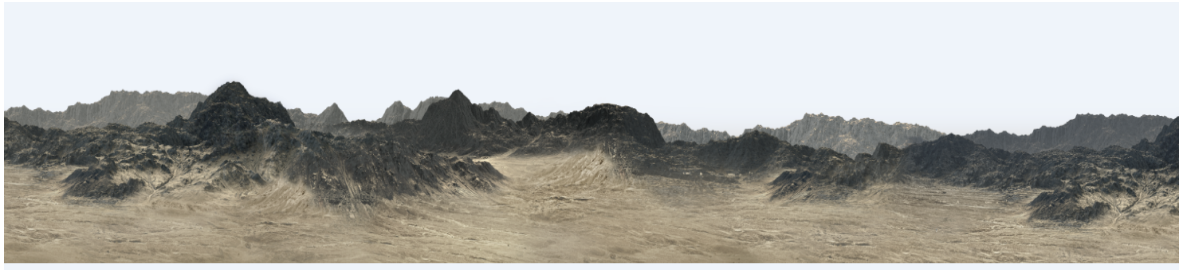
To further push the look more to the photorealism, I have added subtle lighting adjustments, which was really easy to do in 32bit color space using gamma and exposure

adjustment. This technique was also perfect for enhancing the composition, guiding the viewer's eye more towards the desired focal point. To cope with the strong contrast in the most of the night shots, I have used a technique called tone mapping, which basically recovers the dynamic range to the correct levels and also adjusts local contrast and emphasizes details. Sadly use of this process heavily impacted my 32bit workflow and I had to limit its use only for certain shots.

In the end, in the Davinci Resolve, I have added a scanned film grain over the footage to further enhance the realism and also cover the image manipulation so the changes would not be so visible. Only downside of the film grain is compression, which completely destroys it,creating blocky artifacts, which can be only avoided by using lower compression in exchange for bigger files.

10.3 Digital Matte Painting

Matte painting is process of combining traditional painting, digital painting, CGI and photography in order to create 2d, realistic environments, perfect for the shot extensions, backgrounds or wide establishing shots. For the considerable amount of shots, and easier creative manipulation, I have created a few digital matte paints (DMP). To keep the consistency I have rendered multiple landscapes without background and combined them together into one big 5K matte paint which was later used in multiple shots as a set extension or clean plate for retouching material issues that happened in some renderings.



Img 17. Desert DMP

10.4 Color Grading

Primary color grading, prior to any color adjustments in Davinci Resolve was done in the end of the compositing process. Using a set of various LUT's I have been able to quickly achieve the look I was pursuing and then distribute it to the other shots to simplify the later color matching in Resolve. After conforming the footage into the timeline and rough editing, I have pre-graded the footage to match the color and light conditions of the shots in order to achieve continuity in the editing. After the process was done, I have sent the shots to my colleague to do the final grading, since by spending too much time working on the film, I lost my objectivity and therefore I was not able to do the grading properly. After it was done, I transferred the LUTs to davinci and placed them on top of the footage groups. The goal for the color grading was to differentiate the two parts of the film - the night and daytime settings, while keeping overall consistent visual style. The general color theory was used in order to work with certain colours affecting the audience's emotion keeping the atmosphere rather tense and dramatic. To achieve this, we have shifted the upper mid-tones and mid-shadows to interesting colour combinations with a slight tendency towards green, while trying to keep the black and whites neutral. In the end, the decision was made to grade the highlights of the night part more towards yellow to reduce the overall "coldness" of the shots.

Img. 18. Color Grading In Davinci

11 SOUND EDITING AND MIXING

As you may already noticed, I am trying to become a generalist covering as many fields as possible. Although there is a saying "Jack of all trades, master of none", I disagree with that statement, because covering the whole production process gives me ability to communicate my ideas in a much clearer way, and also allows me to think more realistically, knowing each little step of the process and the possibilities. One of the most important aspects of the motion picture is sound. Sound can sometimes be even more important than the visual side, since it can deliver deeper emotional message, and utilizes the creativity and fantasy of the audience.

In my free time, sound design, mixing, and music creation is my way to relax from the visual overload either from school or professional work. Thus I have decided to do my own sound for the film. Most of the film is based on the music anyway and sound design was only necessary in the introduction to better establish the general atmosphere.

11.1 Sound design

I have used multiple sound from my library to achieve the most realistic acoustic image of storm as possible. Starting with layers of rain in various listening perspectives, then adding the thunder strikes and finally mixing in the low frequency sounds to emphasize the epicness of the storm. According to the general acousics theory, the low frequency oscillation at around 70hz can effectively affect the human chest, resonating and creating tension and disturbance in the emotions of the viewer. This effect is widely used in horrors and thrillers, to make the audience more afraid and scared. Adding the low frequency ingredient into the mix also helps build up wider acoustic perspective and adds more depth and clarity.

11.2 Choice of music

Music is definitely the most important decision which drives the whole production and has major impact on the creative processes. As a soundtrack for the film, I have chosen the music by my favourite artist Lorn. Inspired by the song Anvil I quickly created the

screenplay and early sketches exactly to the music. The track is divided into two general parts, the graduating synth themes and more aggressive chorus parts where a lot of drum and percussion sounds are used along with ethereal choirs creating very surreal and and atmospheric effect.

11.3 Mixing

DAW stands for Digital Audio Workstation, which is basically a software used for digital audio editing and post production. For this project, I have decided to return to the favourite software of my teenage years - Steinberg Cubase. It allowed me easily sync the sound with the video and also mix and master the final output. For mixing I have used only built in tools for compression, reverbs and mostly EQ to blend different sounds together without losing the clarity. Important challenge for me was to mix the sound design with the already mastered and produced music without having to affect the final output in any way, so the music stayed in the same quality. The mix was done at 96Khz, which is according to audio engineer Andrew Scheps good enough sample rate to later export in half sample rate of 48khz. As he suggests, there is no point in working with higher rate since the difference between the 96Khz and 192khz is almost inaudible, but the file size and processing requirements are double. Considering that I was mastering the audio into the 24 bit 48khz uncompressed wav, I had to also add some dithering to the master output, to ensure that the quality of the final mix will be consistent with the direct monitoring from the DAW.

Dithering is a process of adding subtle noise to the record, working in similar fashion as adding the film grain to the video. It will ensure that no stepping of the waveform will occur, in other words there should be no distortion in the sound caused by lowering the sample rate. The mixing and sound editing process was done using RME Babyface Audio Interface (high end level sound card), and monitored on KRK monitors in combination with Audio Technica studio headphones, to ensure that the mix will translate well to the standard consumer speakers.

CONCLUSION

This project served as an opportunity to demonstrate years of training in CGI and visual effects and also as a perfect practice to develop advanced workflow and understanding of the particular tools. During the last year, I was able to strengthen my skills in various fields of animation, look development, modeling, rendering and compositing, effectively utilizing and exploring various solutions to everyday challenges given by the complexity of the project. This written study gives the reader broad view of the industry standard processes and explains the difficulties in applying such workflows in the small team or freelance environment.

Thanks to this project, I was also able to develop a set of new skills such as retopology, motion capture, color grading, cinematography, particle effects and many more. As you can see in the amount of steps needed to accomplish this journey, it is obvious that such films are almost exclusively made only by studios and only small amount is done by freelancers or individuals.

However, the recent breakthroughs in technology might change this soon. Each year the computers are getting faster and faster, and software catches up, rapidly lowering the amount of time required for rendering or simulations. This allows people like me to get good results even with a very small budget.

To conclude, I am glad that I decided and persisted in doing such challenging project without stepping back to the comfort zone. Revelation of new workflows and rapidly speeding up my habits enabled me to do a lot of the final shots in a fraction of time that it would take six months ago. This also motivates me to not just focus on the technology, but more importantly, on the ideas I can communicate. In the near future, I am planning to focus on more projects like this to continue with the practice and prepare myself for the new challenges. However, in the recent weeks, under the pressure of stress and extreme sleep deprivation, I felt depressed and lost my focus on this project. But only a few days ago, I proved myself that it all have been worth, seeing that I was quickly able to develop and produce last shots of the film in such a short time with pretty satisfying results.

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LIST OF ABBREVIATIONS

CGI	Computer Generated Imagery
CG	Computer Graphics
NLE	Non-Linear Editing system
DAW	Digital Audio Workstation
OFFF	Online Flash Film Festival
FITC	Flash In the Can (Canada)
LUT	Look Up Table
EQ	Equalizer
DMP	Digital Matte Paint

LIST OF IMAGES

LIST OF ATTACHMENTS

ATTACHMENT A1: SCREENPLAY OUTLINE

1. A storm on unknown planet.

2. A strong ray of light emerges from sky.

3. An astronaut is being slowly lowered down trough the light beam.

4. After he is put on the ground, the light dissapears.

5. Morning, the astronaut wakes up.

6. Astronaut looks around.

7. Astronaut wanders trough the vast, endless desert.

8. He comes to the huge crater to behold a giant unknown object howering above.

9. He take out a small fragment.

10. Releases the small fragment towards the monument.

11. The fragment connects with the monument, and the gravity on the planet is suddenly gone.

12. Astronaut starts to hover above the ground and slowly rises up.

13. Astronaut flies over the energizing monument.

14. The monuments creates strong beam of light around the astronaut.

ATTACHMENT A2: SCREENPLAY

EXT. Unknown Desert - Night/Storm

We are in the middle of the raging thunderstorm, on an unknown place in the desert. We observe the environment trough various perspectives from air and from the ground. Suddenly after a lightning strike, a beam of light appears and slowly touches the ground. The light is so bright it lightens up the whole desert, making the hilltops drop long shadows over the watery sand.

EXT. Unknown desert - Beam of light

We are approaching the beam of light until we see a figure, hovering and slowly comming down from the sky. The figure is an Astronaut. We don't know where he came from, but he seems unconscious and lightly levitating in the beam of light full of flowing particles.

We are following the astronaut down on the ground, until he is put there and left for the rain to pour over his suit.

EXT. Unknown desert - Ground

As he touches the ground, the invisible power, holding him from the forces of gravity starts to fade out, leavin g the motionless body abandoned in the middle of the nowhere. Suddenly, the light starts to fade away as well, covering the scene in to the utter darkness.

EXT. Unknown desert - Morning

We observe the sunrise over the mountains. As the sun is moving above the horizon, a streaks of light break trough the softly overcast sky and highlights the parts of the rocky hills. We cut to the astronaut lying on the ground slowly moving his hand and waking up. As he stands up, he looks around in order to identify the landscape and estimate his location.

EXT. Unknown desert - Day

In a short montage of closeups and aerial shot, we are following the spacemen, wandering trough the land towards the invisible destination.

EXT. Unknown desert - On the edge of the crater

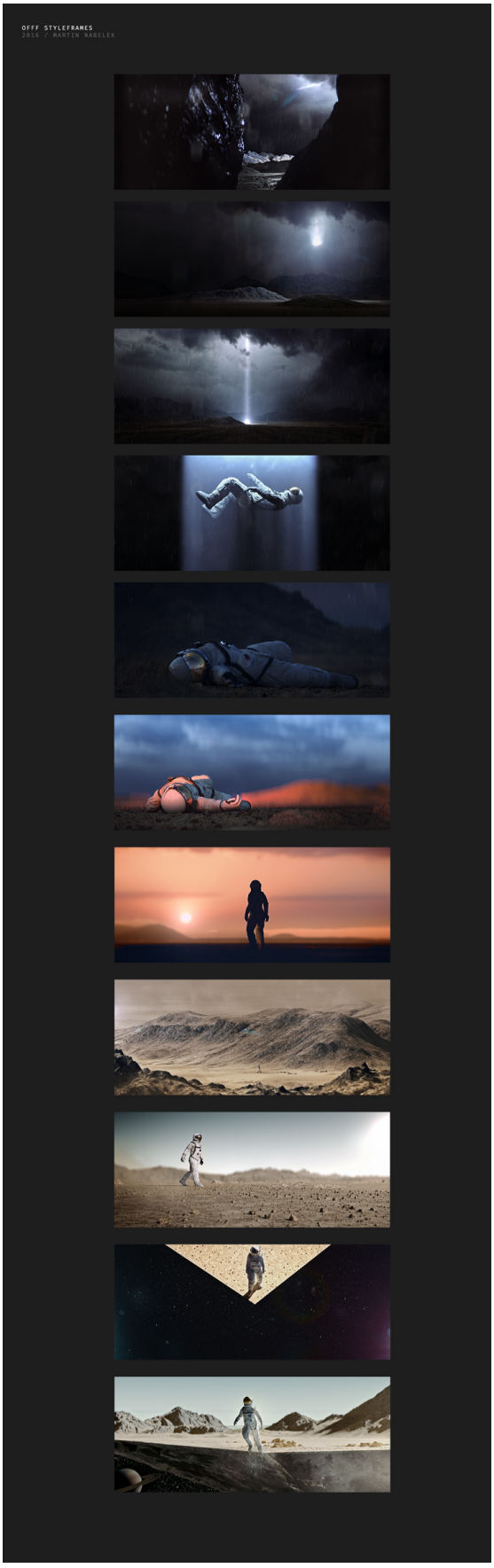
The astronaut steps to the edge of the giant crater. As he looks up, he beholds a huge, black monument floating in the sky, slowly revolving. The spacemen takes out the small black fragment out of his pocket and decides to take a closer look.

After a while he stretches his arm and releases the small black object out of his palm. Unexpectedly, it does not fall on the ground, neither stays in his hand. It starts to hover and takes off towards the gigantic monument. Astronaut is watching the element dissapear in the distance when suddenly the gravity stops to hold him on the ground. In a shock, he realises he is not standing on the ground anymore, but hovering above the crater instead. His body is rising, similarly to the small mysterious element he has just released and we observe him as he flies away. As he is rising towards the sky, the landscape rotates and the world becomes suddenly and literally upside down. We are watching the spacemen fly over the tip of the monument further to the space.

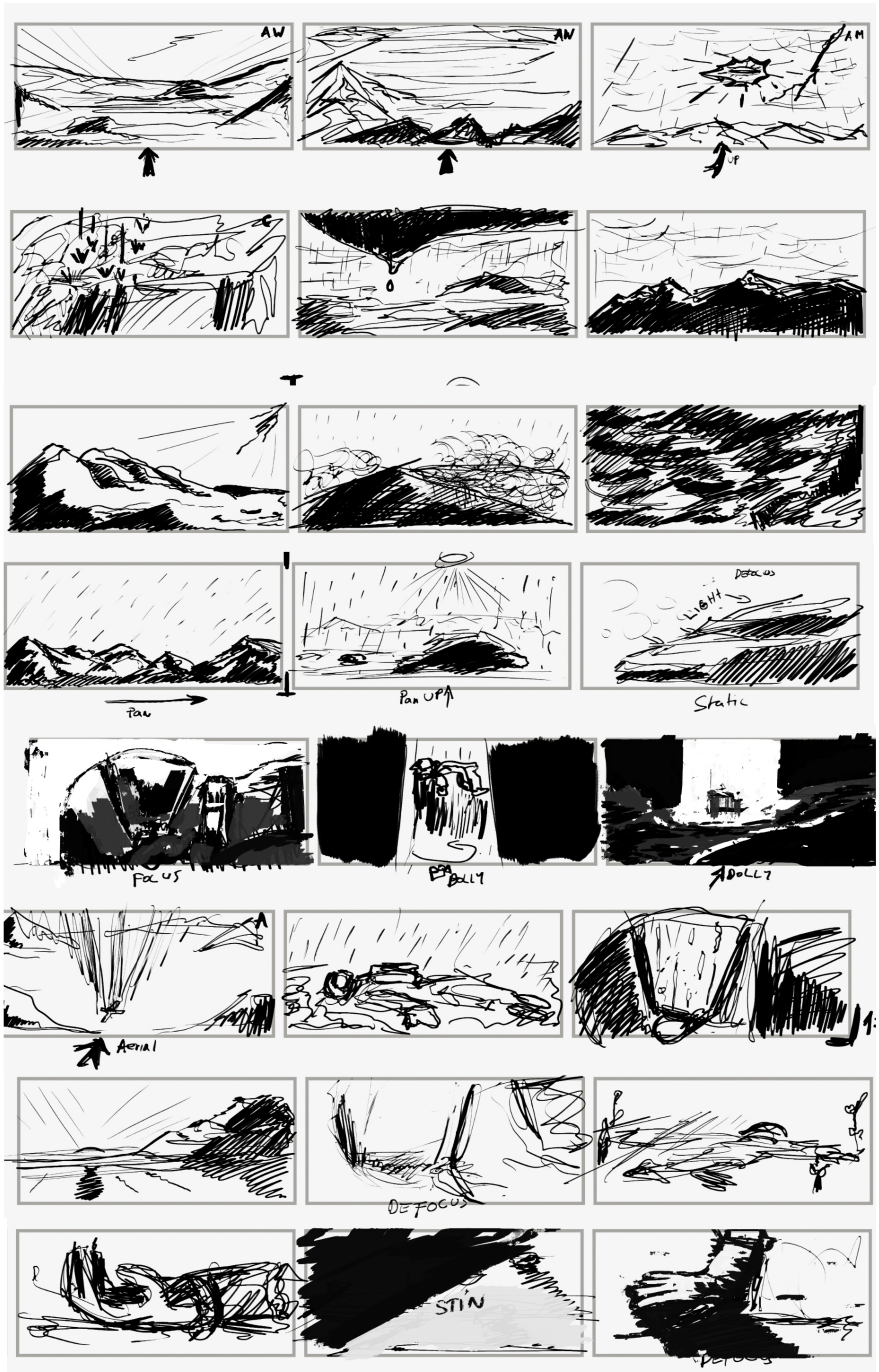
EXT. Space

From far away, we see the astronaut being lit by the strong beam of light emerging from the black monument. The light stream strongly resembles the one that carried the astronaut to the planet in the first place. The scene goes dark and we can only guess what happens next.

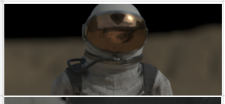
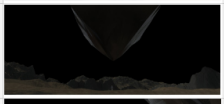
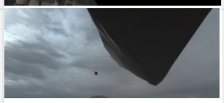
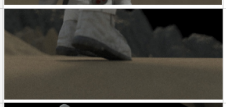
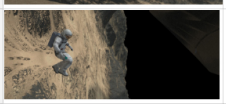
ATTACHMENT A3: ORIGINAL STYLEFRAMES



ATTACHMENT A4: STORYBOARD - PART 01



ATTACHMENT A5: STORYBOARD - PART 02

	SHOT SCREEN	SHOT NAME	CAMERA	FRAME RANGE	ASSEMBLY	ANIMATION	RENDERING	CAMERA_EXP	COMPOSITING	EXPORT
2		**E_SH01**	CAM03	100-175					V2	
3		**E_SH02**	CAM02	90-190					V1	
4		**E_SH03**	CAM04	200-350				N/A	V1	
5		**E_SH04**	CAM01	180-280				N/A	V1	FIX SKY
6		**E_SH05**	CAM05	400-550					V1	
7		**E_SH06**								
8		**E_SH07**								
9		**E_SH08**	CAM02	600-700					V1	
10		**E_SH09**	CAM06	630-730				N/A	V1	Add stones rising
11		**E_SH10**	CAM07	750-850					V1	Add stones risin
12		**E_SH11**	CAM08	1150-1290					V1	

ATTACHMENT A6: FINAL FRAMES FROM THE FILM