Commercialization of a High Altitude Platform

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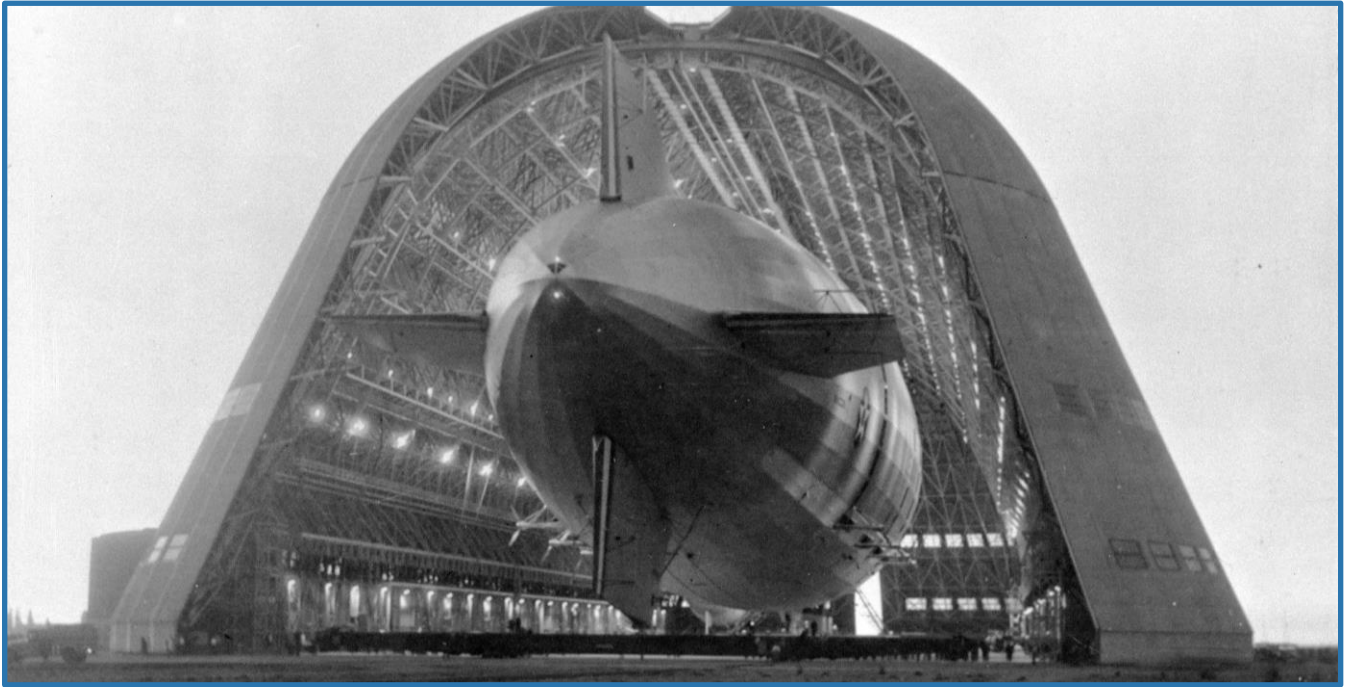|	
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Fig 1. - Hangar 1 Moffett Field (Static1.1.sqspcdn.com, 2016)

Abstract

Starting a business in any endeavor is considered to be a laborious task fraught with failure, late nights, and a spartan lifestyle. I have been honored to say that this is all true to a certain extent. It is also an extremely rewarding experience despite the difficulties encountered in such a venture. This report seeks to convey to the reader my experience of one such startup through the International Space University's Masters program and my internship at NASA Ames Space Portal. The report is divided into two primary sections which chronicle my time. Part I is comprised of "The Basics" of the project which provides background and context of the proposed business to the uninitiated. The basics needed to be redefined upon arrival at space portal and this refinement is covered in this section. Part II details "A New Direction" where we transition from the basics to a new plan for the project and the work accomplished. This section covers the second half of the internship.

Acknowledgements

To Orla, who climbed on this ride with me from the start, with no plan on getting off. This internship was one of the hardest things I had to do because of your absence, but your support from a distance inspired me to continue to push the boundary of what I could accomplish here.

To David and Makthoum, you two have always believed in me and this project. We wouldn't be where we are today without the blood, sweat, and tears you've poured into realizing our vision.

To Walter Peeters for consistently challenging our team to do better throughout the development of UNSP.

To Darlene for being flexible and encouraging of me here at NASA Ames. Your guidance demonstrates your ability as not only a fantastic coordinator, but also a mentor.

To Dan and Bruce. Your constant advisement and peerless work ethic challenged me to think and perform at a higher level. It was a privilege to learn from both of you.

To the Space Portal team. It was humbling to witness your unmatched passion for space. Everyone here embodies the spirit of innovation and challenging the status quo. It was an honor to work with you all.

Finally, to all of those who still believe in crazy dreams. Who demand a reason for continuing than a reason to stop. That the pursuit of all great and worthy ventures requires a conviction to stand opposite of safety and comfort. The work we do is for you.

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Abbreviation & Definitions

ATC - Air Traffic Controller

C3I - Command, Control, Communications, and Intelligence

DOD - Department of Defense

ECLSS - Environmentally Controlled Life Support System

EO - Earth Observation

FCC - Federal Communications Commission

HAB - High Altitude Balloon

HAP - High Altitude Platform

ISR - Intelligence, Surveillance, Reconnaissance

JLENS - Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System

JSTARS - Joint Surveillance Target Attack Radar Systems

LCDR - Lieutenant Commander

LMDS - Local Multipoint Distribution Services

LTE - Long Term Evolution

MBPS - Megabits Per Second

MK - Mark (Model / Version)

MMDS - Multichannel Multipoint Distribution Services

MVP - Minimum Viable Product

OEF - Operation Enduring Freedom

OIF - Operation Iraqi Freedom

PPTS - Point to Point Transportation Solution

PTDS - Persistent Threat Detection System

ROF - Reduction of forces

SAM - Serviceable Available Market

SOM - Serviceable Obtainable Market

STEM - Science, Technology, Engineering, and Mathematics

TAM - Total Addressable Market

TOS - Time on Station

TRL - Technology Readiness Level

UNSP - Universal Near Space Platform

Warfighter - A military servicemember (In this case, one that serves in the U.S. Military)

WIMAX - Worldwide Interoperability for Microwave Access

WRAN - Wireless Regional Area Network
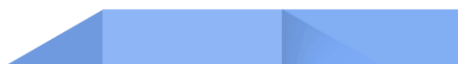
Introduction

I came to the NASA Ames internship committed to continue the development of the UNSP (Universal Near Space Platform) project, which has progressed significantly since its beginning in Fall 2015. Since then, much molding has taken place, with my internship acting as a compass for future development. Upon arrival at the space portal office which I worked during my time at NASA, a summarized description and review of the project was necessary. This allowed the mentors at the space portal to understand the internship project, what our objectives were, and what necessary actions needed to take place for the project to succeed. From this, we focused our attention on the communications market as our primary target for entry. I conducted market research into this area for several weeks, then after a presentation, determined a new direction for our project. We launched this new venture titled 'Raven Bold' that provides services to underserved communities such as internet service quality reports and assessments. From this foundation, we launch our pilot program of providing internet access. After reaching out to several underserved communities, we are now (as of mid-August 2016) in cooperation with one of the counties to discuss internet deployment options to unserved areas within their region. I begin this report with the overview of our project I provided to my mentors. For a more in-depth understanding of the UNSP, please refer to the individual report provided earlier this year.

The Basics: Project Overview (June)

Overview

Unity is a "to be started" business that intends to service multiple markets with the UNSP. The UNSP is a persistent, high altitude platform able to provide a spectrum of services due to its

unique ability to maintain a fixed position over the Earth for extended periods of time. The station is composed of high altitude balloons* attached to a truss system of arms and a central hub. Below this central hub is where payloads are intended to sit, with future versions allowing multiple, suspended payloads. The station keeping ability of the UNSP combined with its extreme lifting capacity make it suitable for an array of applications, anywhere in the world.
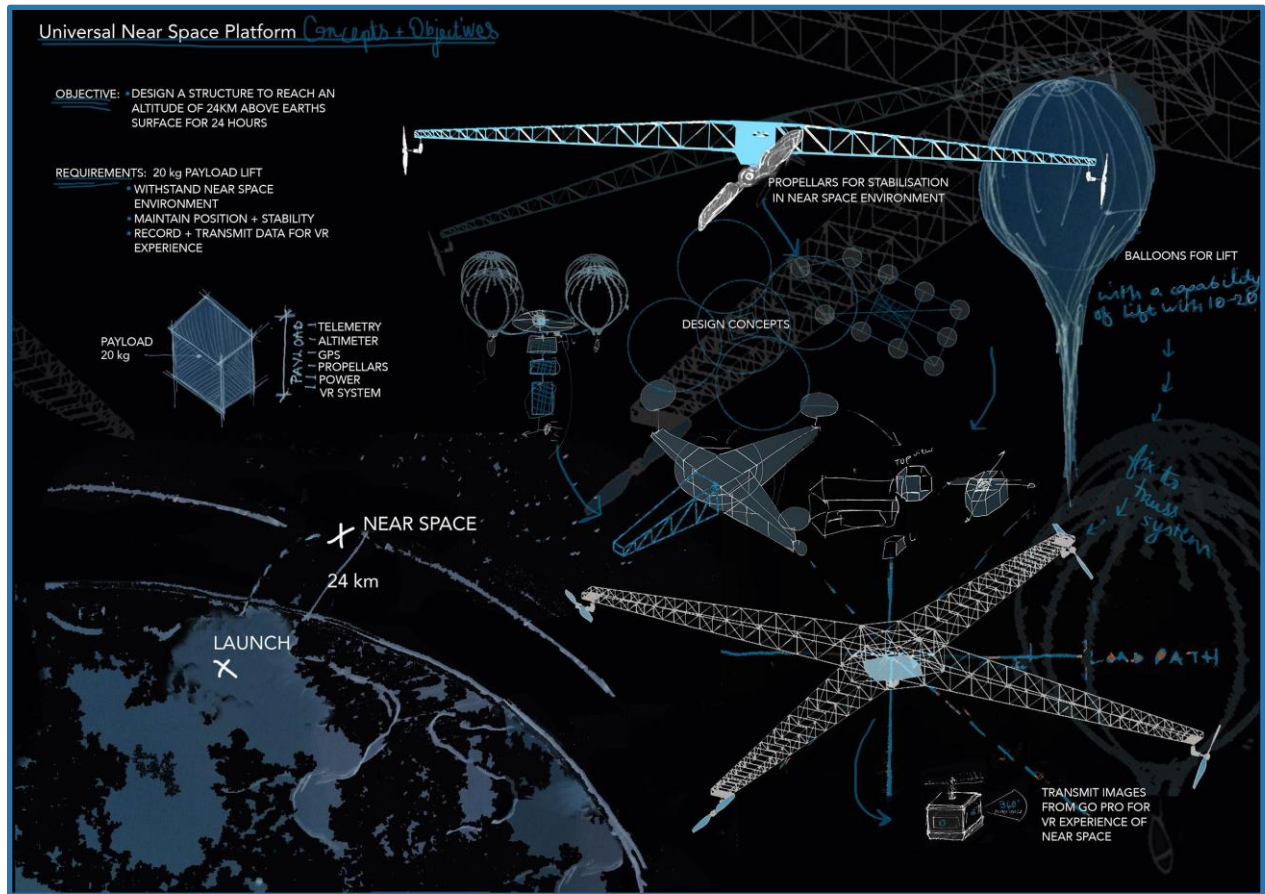
Fig. 2 - UNSP Concept Art (O. Punch, 2015)

*Development version level dependent (MK (Mark) I & MK II Prototypes currently use high altitude balloons. Future iterations will utilize airships for heavier lift capacity and overall improved flight performance.)

The UNSP project began in Q4 of 2015 with a pitch of the project to fellow ISU classmates, resulting in several students showing interest. The UNSP project then became apart of the "Unity" startup business plan. Our original team can be seen below:

Team Structure

Team UNSP was comprised of several levels of individuals with varying degrees of involvement and expertise. These ranged from students to professionals, who all possess a passion for space.

The Core:

The core team was comprised of 4 members and made up the official roster for the ISU open day. All 4 members were highly committed to the success of the UNSP and despite setbacks, fully intended to realize the vision of making space more accessible through high altitude platforms and education.

Fig. 3 - Core Team (UNSP Team, 2015)

Additional Support:

Although the Core team was the primary engine for moving the UNSP forward, such a bold endeavor could not be attempted without the feedback of advisors and the assistance of a support team. The advisors provided a grounded and objective analysis of UNSP progress and overall sustainment while the support team provided expertise in areas outside of the core team's skill set.

Fig. 4 -Advisors (UNSP Team, 2015)

Fig. 5 - Support Team (UNSP Team, 2015)

Our current team has seen some changes from our original team. David, Makthoum, and myself are the only full time members, while our primary support member who still assists us is Orla. Our advisors are still available but no longer maintain a direct role. Our current advisors are the team at Space Portal. Our team and advisors will likely continue to see reshuffling as the project progresses through development.

The Technology of the UNSP

For those that desire to utilize high altitudes, the fundamental problem lies in the ability to reach and stay in Near Space (65,000 ft. to 325,000 ft. / 20 km. to 99 km (Space.com, 2016)). At this altitude, the problems faced by many can be addressed effectively with a combination of several core features:

- Station Keeping / Time on Station
- Reaching Near Space Altitude (65,000 ft. / 20 km+)
- Endurance (Weeks to Months)
- Lift Capacity

- Payload interface
- Point to Point mobility

Fig. 6 - UNSP model in flight (UNSP Team, 2015)

Flight Versions

The UNSP is comprised of several flight models or "Mark" versions.

MK I - Originally designed to be the image above, MK I was rehashed in order to accommodate the tight time schedule and other obligations the team had during the year. MK I became a single high altitude balloon attached to the central hub, without the arms of the structure. Below the hub would sit the various payloads:

- Propulsion system (Utilizing a high altitude propeller design)
- Stabilization platform
- Power supply
- Communications / Navigation / Telemetry hardware

Additionally, a cutaway system was devised in the event of an emergency.

MK II - The second version of the UNSP reflected the MK I, but possessed the arms distinctive of the UNSP. The arms allow multiple high altitude balloons to be attached to the structure allowing

a greater lift capacity. The greater lift capacity would allow more advanced equipment to be brought aboard the platform along with greater flexibility in station keeping.

MK III - Although never fully designed, the third iteration of the UNSP would be the final design that included balloons as enough data would be collected by that point to begin development of more advanced versions.

MK IV+ - The MK IV and beyond would begin to include airship designs that would replace the balloons and structural materials built to withstand heavier loads that would come from the greater lift capacity afforded by the airships. Many aspects of the UNSP would be greatly improved with the MK IV version. The MK IV would be the first iteration of the full scale, service version of the UNSP.
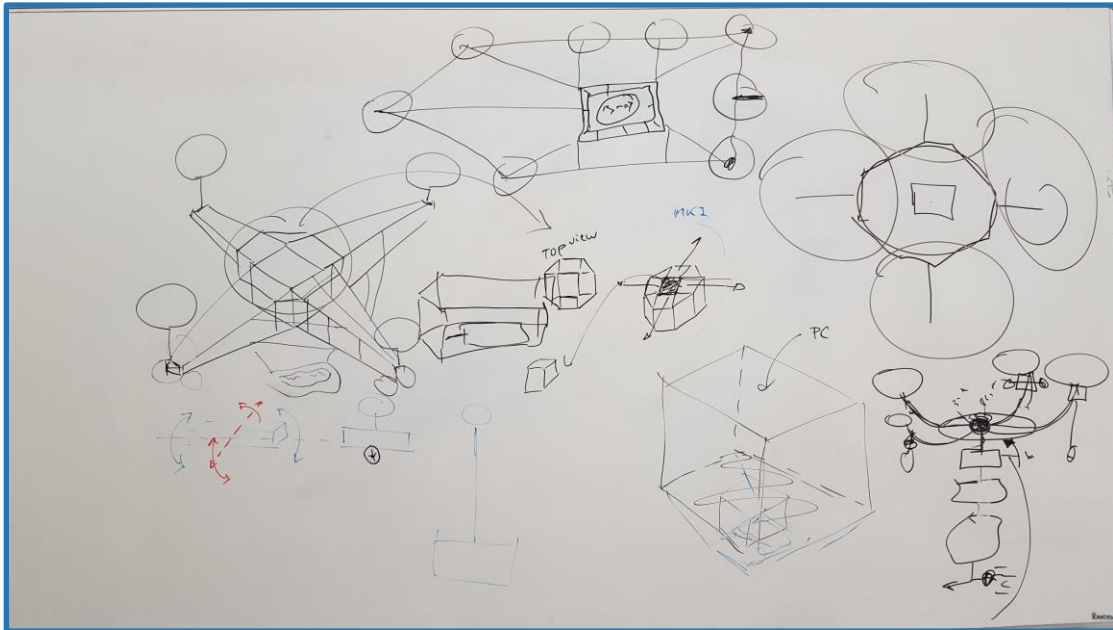
Fig. 7 - Core Team Whiteboard Brainstorm UNSP MK I & II (UNSP Team, 2015)

Structure & Envelope Material

MK I and MK II designs would utilize cheaper lightweight materials such as carbon fiber rods arranged in a truss for the structure. The envelope material would be either Chloroprene or Neoprene as these are the standard for many high altitude balloons (Stratoscience, 2015) Later versions would likely utilize more advanced composite materials for the structure and the envelope materials would likely consist of high grade polyethylene and other high grade fabrics

(material can range from Vectran and Tedlar to Mylar and Polyurethane). As MK IV airship designs are still awaiting development, it cannot be stated with certainty what materials would be used in the MK IV+ envelope designs.

- *Why a Truss?* The triangle is the strongest and most stable shape, which when arranged in an interconnected series, becomes a truss. The truss design has several key advantages (Steelconstruction.info, 2016):
    - Extended Length (significant in that the airship design for MK IV+ will be relatively large requiring a large structure.)
    - High strength to weight ratio.
    - Durable against bending/twisting (little deflection).
    - Supports extreme loads (significant to hold the increased lift capacity afforded through multiple airships.)

Power

Like the Thales Stratobus (Thalesgroup.com, 2016), the UNSP intends to use solar collection to generate power to the payload, propulsion, and various other subsystems aboard the UNSP. The altitude at which the UNSP will operate is a boon to this type of energy use. Flying above the weather results in predictable and consistent solar power which enables the UNSP to have an increased endurance. The ability to station keep for long periods of time would be a moot point however, if the mission payload is unable to function due to a lack of power. The endurance of the UNSP and the endurance of the payload directly rely on the power availability. The massive surface area of the UNSP would be conducive for installing extra solar panels in addition to those already fixed to the airships.

Attitude Control / Station Keeping

Advances in the last decade of renewable energy resources and storage have enabled HAPs (High Altitude Platforms) to be considered for station keeping purposes (Colozza, 2003). The mobility of the HAP however must be viewed through a holistic lens as multiple factors affect the final endurance duration. These factors include:

- The environment within which the HAP operates.
    - Latitude and seasons affect sunlight availability. For instance, many high altitude balloon projects are launched at the poles due to the near constant availability of

light, bypassing the effects of a normal diurnal cycle. This advantage reduces drastic altitude changes due to the density fluctuations caused by the heating and cooling of lifting gases (Asd.gsfc.nasa.gov, 2016).

- Mission requirements
- Power storage type
- Propulsion system
    - High altitude propellers have been studied, with recent designs within UNSP pointing towards a contra-rotating propeller as the most viable solution for stratospheric applications.

Fig. 8 - Component Breakdown for a Power / Propulsion System Module (Not to Scale)(Colozza, 2003)
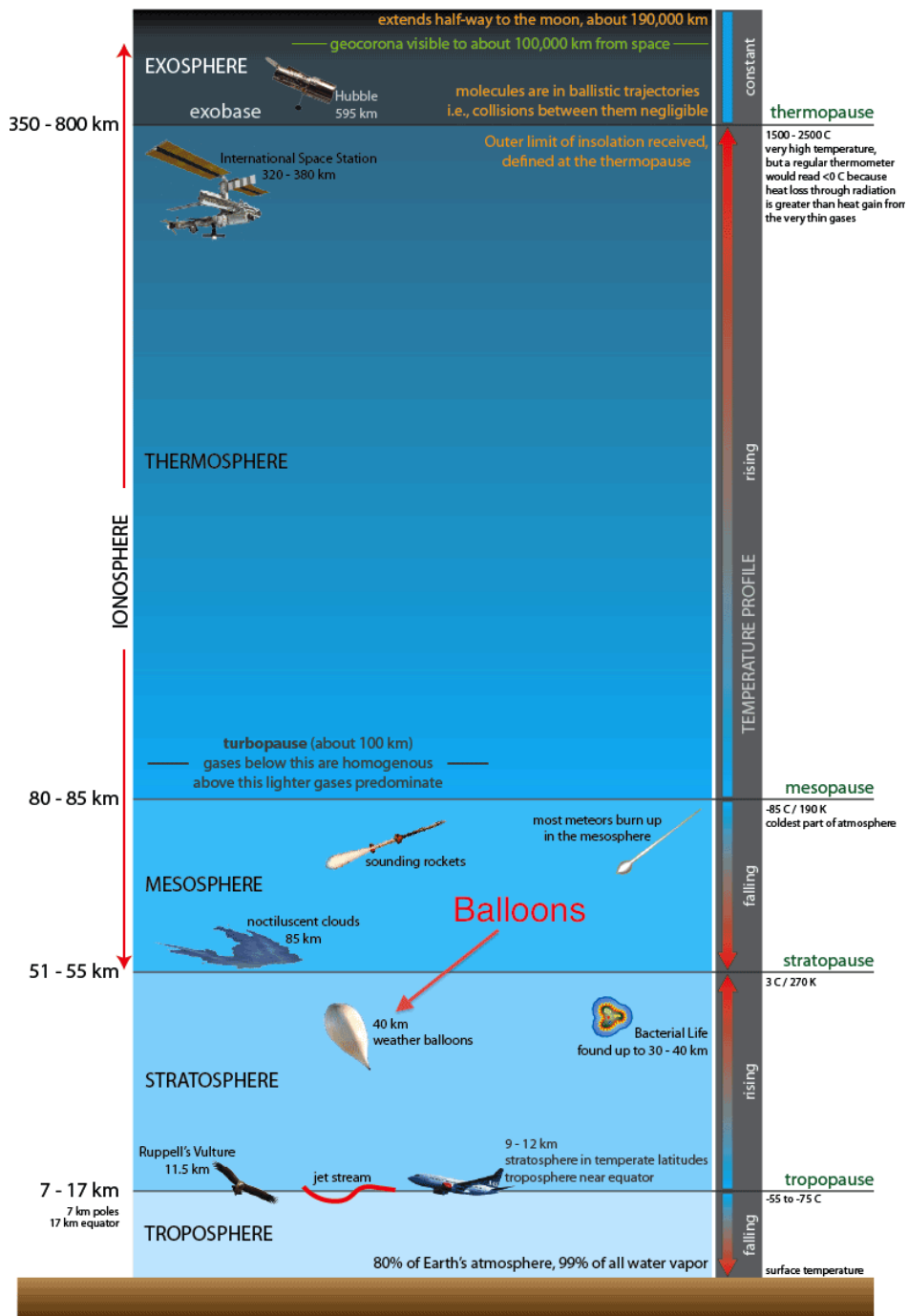
Fig. 9 - Atmospheric Profile (Community.balloonchallenge.org, 2016)

Operation

Operating at the 20 km - 40 km altitude is beneficial for various markets. Some HAP infrastructure proposals subscribe to a service provider or capacity lease model. The UNSP with its versatility can also modify the capacity model and lease payload weight capacity as well as a hybrid model. Each payload can be suspended in an array of ways depending on the requirements of the customer. Some may need to unobstructed view of Earth, and others the sky. The operating altitude, endurance, and lift capacity of the UNSP allows this.

The review above established the the state of the project to the mentors. A thorough understanding of the technology of the project, but also the vision, enabled the mentors to establish the best strategy for utilizing my time effectively during the internship. We've found that focusing on the right objectives is just as important as the work itself.

The Basics: Our Markets (June)

The month of June was seen as a time for acclimating ourselves to the environment and to the rhythms of the space portal office. During this time I gave a presentation of the above overview, but I also went over the established markets. The purpose of this was to demonstrate the commercial viability of the UNSP and our primary areas for growth of Unity.

Problem, Market, and Opportunities

The unparalleled capabilities of the UNSP lend itself to a diverse range of applications in varying markets. Each market has its own benefits and disadvantages which influence the sequence in which each market should be approached. For example, several markets are more lucrative than others, but the barrier to entry may be higher. The team originally identified several market opportunities and business problems along with them. These are the clearest and direct markets that our team had assessed would benefit most from the use of the UNSP. For brevity, I have excluded the more detailed sections found in previous reports and present only the basic overview presented during my internship.

Overarching Problem: <u>Regular access to Near Space is non-existent.</u>

Education

Problem: Schools do not have the ability to conduct extended research in Near Space.

UNSP Solution

The cost of access to Near Space for schools is an opportunity many schools do not account for in STEM (Science, Technology, Engineering, and Mathematics) curriculum. Access to a scaled, cheap method of repeatable data collection via a persistent Near Space platform such as the UNSP is an exciting opportunity for these schools to involve students in various STEM skills.

An "Educational Flight Model" of the UNSP would be delivered to the school as part of a STEM engineering kit. The flight model would be able to deliver various payloads to Near Space, where they can collect data not only from Near Space but of other areas due to the kit including:

- (Astronomy) Telescope pointed up to see stars
- (UNSP / Flight Monitoring / Telemetry) A camera and sensors to observe near space and the UNSP
- (Earth Observation) A telescope pointed down to observe the Earth and track:
    - Weather
    - Traffic
    - Day / Night
    - Patterns
- Arduino / Programming language to run software (Tablet to turn on and run)
- Communications kit

Communication

Problem: Current communication networks have limited capacity, coverage, and capabilities. Mobile, Television, and Internet currently have not seen a significant enhancement In delivery technology in decades leading to only marginal improvements in speed, coverage, and content quality.

UNSP Solution

If Satellites are globally focused, then the UNSP is a perfect regionally focused compliment. The UNSP would be an introduction of a *new* type of delivery system that combines the benefits of other transportation methods. In contrast to other high altitude platforms such as manned

airplanes or UAVs, HAPs are considered to provide the highest quality, most reliable, and affordable communications options. However, HAPs despite their versatility are hampered by their lack of heritage and unique design characteristics. Their benefits outweigh their cost however. Current telecommunications rely on two primary networks - satellite and terrestrial - for data delivery worldwide. The introduction of the UNSP would function as a third network that would seek to augment and embed itself within the other two networks, massively increasing quality, reliability, and speed. Areas of which it could contribute include (42):

- Mobile Cellular
- Wireless Regional Area Network (WRAN)
    - The UNSP can deliver WIMAX (Worldwide Interoperability for Microwave Access) or another city wide wireless internet, which serves as an alternative to conventional fiber optic/cable internet at home. Implications: *Consumers no longer need to use an ISP that runs cable into their home or need a modem etc...a wireless adapter on their device is the only requirement.*
- LMDS (Local Multipoint Distribution Services) / MMDS (Multichannel Multipoint Distribution Services)
- Digital Video Broadcasting

Space Tourism

Problem: Options for affordable space access are non-existent.

UNSP Solution

The UNSP will function as a gateway for people to come to know space in a different context, as they become participants instead of observers. The low cost of the UNSP and the ability to carry multiple people not only makes space tourism accessible to more people, but increases interest in Space overall, furthering support for programs which increases funding.

Intelligence & Defense

Problem: A reliable, low-cost, observation and communication platform with extended TOS (Time on Station) duration is non-existent.

UNSP Solution

UNSP will cost a fraction of the alternatives while delivering better capabilities (Global Hawk price - $222.7 million per aircraft, which still needs refueling and is limited to a 3,000 lb payload, and has a rough cost of $19,000 per flight hour as of 2013 (Government Accounting Office, 2013).

The UNSP as a service instead of a hardware platform operated by servicemen typically adopted by the military can cut costs by providing integrated software tailored for the warfighter while delivering unmatched support and customization. Akin to the military switching to the ease of Apple OS X but the customizability of Windows.

Supply Chain & Transport

Problem: Current transportation networks are limited in vehicular delivery options (e.g. - overland is truck or airplane, over water is ship or airplane).

UNSP Solution

Current point to point transportation solutions (PPTS) are subject to weather considerations, with delays and cancelled routes affecting delivery to and from austere environments and certain times of the year. This leaves the UNSP less affected by weather during flight.

The UNSP can also function from a high altitude by dropping cargo safely without loitering during load/unload procedures ('Skyhook' capabilities are currently being explored)

Current PPTS Airships use Helium. UNSPs unique safety bladder prevents leaking and acts as an additional safety measure for the Hydrogen gas used as lift.

UNSP will be able to lift loads many times greater than current offerings, mitigating road hazards of trucks transporting heavy machinery, large custom parts, and even houses.

UNSP tracking integrates easily with tracking software/manufacturers to allow for better decision making to stakeholders, and can act as a solution for delivery businesses such as UPS or FEDEX unable to meet demand. (I.e. - Offered by Fedex/UPS but operated by UNSP).

Scientific

Problem: Scientific institutions spend significant resources for access to Near Space in order to conduct research.

UNSP Solution

Scientific benefit of the UNSP is tremendous if used for the range of missions that many foresee HAPs to provide for the scientific community such as:

- Astronomy from a HAP
- Atmospheric studies
- Oceanographic monitoring
- Meteorological data gathering
- ECLSS (Environmentally Closed Life Support Systems) development
  - Analog missions

The long duration of the UNSP would allow scientists to conduct long-term research previously unable to be accomplished by high altitude research aircraft such as NASAs ER-2. In essence, the benefit of the UNSP would be most seen in the Astronomical community that looks up from the platform, and where many papers have been written in support of such a capability (Fessen, 2007).

HABs (High Altitude Balloons) typically used by the scientific community such as NASA which has one of the longest durations of any of the suite of HAB/HAPs (Rainwater and Smith, 2004) is 3 months and expected to increase to 6 months to a year with further testing. These HABs provide the benefit of being above 99% of the Earth's Atmosphere while being able to return payloads quickly unlike typical space launched payloads. However between both of these, UNSP offers the safest return of the payload as there is no crashing via parachute into the land or sea.

Other

A multitude of other uses exist for the UNSP that could develop into viable markets if expanded into correctly. Several are listed below:

- High Altitude Skydiving
- Ashes scattering
- Rocket launches
- Disaster Mitigation / Response
- Oil and Gas
- Asset Tracking
- Border/Policing/Security

- Mapping

Fig. 10 - UNSP Open Day Booth with David, William, and a poster of the UNSP (UNSP Team, 2015)

Market Selection

In the end, the UNSP is capable of various types of missions and is adaptable to many situations. This benefit is comes from the teams focus on the core functions of the UNSP which deliver the most benefit to all customers - A point to point, station keeping, high altitude, long endurance platform. When accomplished by the UNSP, every market can be serviced effectively regardless of the mission. The UNSP may not be considered a catch all solution to every market, as some needs can be better addressed by other mission specific platforms. However, by hitting our primary capabilities - lift, endurance, station keeping, and altitude - the UNSP can be the primary alternative to the costly perfect solution.

An 80% solution still requires a starting point however. An unfocused requirement leads to suspended progress as direction is unclear. The feedback from the mentors after presenting our various markets and outlining the strength of the UNSP revealed that no one is our customer if

everyone is. Therefore, as we had suspected since our entrepreneurship elective at ISU, we needed to pick a market and push forward. After looking at the activity, barriers to entry, the minimum viable product (MVP), and the projected breakeven points, we assessed that the communications market had the greatest potential for entry. The intelligence & defense market barriers to entry were high and along with the scientific market, relied solely on the government for subsistence. The education and space tourism market were not deemed sustainable, and supply chain was assessed to have an MVP too high for initial investment. In the next section we outline the reasoning for the selection of this market and the expected benefits.

A New Direction: Communications (June / July)

Fig. 11 - Moffett Field / NASA Ames Research Campus (Wikimedia, 2000)

Setting communications as the primary market for Unity to enter helped spur a renewed vigor in the team. The market needed a much deeper investigation than the cursory summary we had done in our first identification of markets. It wasn't till reaching the halfway point of the internship

that I was able to display the communications market research in a venture capital style pitch. Below, I present the reasoning why the communications market is considered by our team to be the most suitable market for an entry level UNSP.

Problem

Internet service providers (ISPs) in the U.S. are considered by world ISP standards to be substantially subpar. Unlike many other industries, the broadband delivery market is organized in such a way that competition in the wireless and wired markets has been reduced to a only a handful of players. This has left many newcomers to the market unable to compete due to high barriers to entry, resulting in meager internet service quality. In order to fully understand the problem however, a deeper look at the component problems is required:

Differentiation

The problem isn't necessarily availability of broadband. Over 90% of the country enjoys download speeds over 10mbps (megabits per second) (National Broadband Map, 2016), the FCC considers 10mbps to 25mbps reasonable for households that stream (Consumerreports.org, 2015). The FCC also considers broadband to be speeds over 25mbps (Broadcastingcable.com, 2016). However, the problem stems from ISP differentiation.
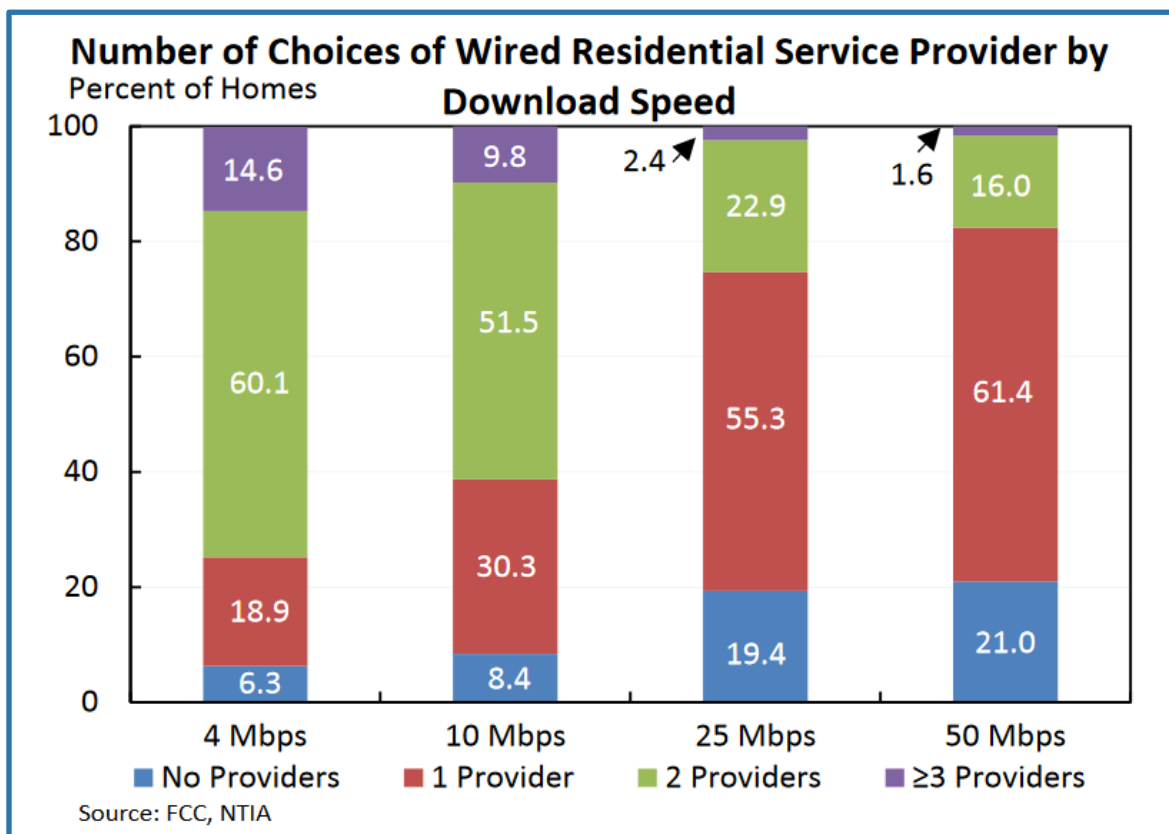
Number of Choices of Wired Residential Service Provider by Download Speed

Percent of Homes

	4 Mbps	10 Mbps	25 Mbps	50 Mbps
≥3 Providers	14.6	9.8	2.4	1.6
2 Providers	60.1	51.5	22.9	16.0
1 Provider	18.9	30.3	55.3	61.4
No Providers	6.3	8.4	19.4	21.0

■ No Providers ■ 1 Provider ■ 2 Providers ■ ≥3 Providers

Source: FCC, NTIA

Fig. 12 - Consumer ISP Choice (Whitehouse, 2015)

From the graphic above, we are able to see that 10mbps is accessible through 1 provider or not at all to 40% of the U.S. Population. Additionally, the broadband speeds the FCC has labeled at a minimum of 25mbps are not available to over 75% of the population (Whitehouse, 2015). This results in a natural Oligopoly of only a few ISPs who can provide subpar service at a terrible price.

Price

How do we know that the prices are terrible? By comparing current prices in the U.S. to those in the rest of the world. According to the White House, the U.S. nationwide charges more across ALL ranges of internet speed. The 16-30 mbps range sees almost a $30 difference. We can also see speeds above 75mbps are offered in very few cities, which leads to our next category.
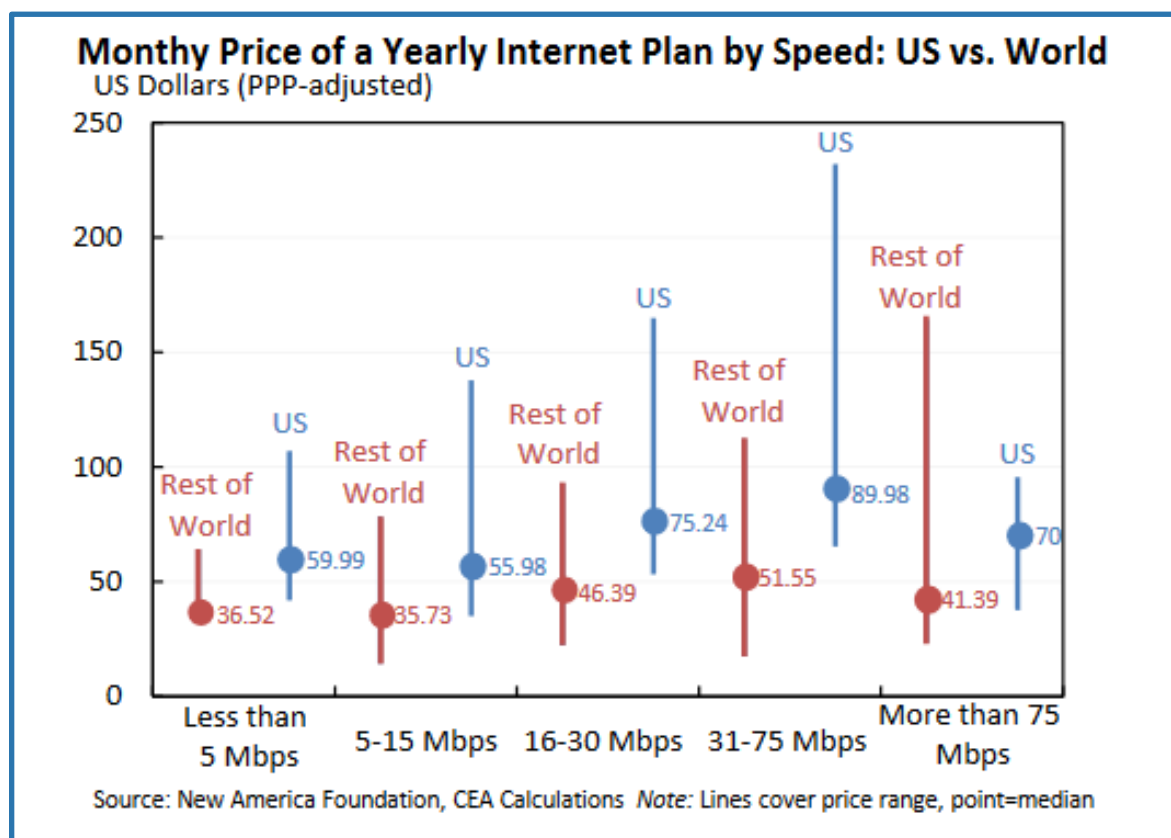
Fig. 13 - U.S. Internet Service Plans by Speed vs. World (Whitehouse, 2015)

Speed

Despite inventing the internet, the U.S. consistently places in the double digits in worldwide internet speed ranks. Ranking anywhere between 20 to 30 any given quarter depending on the source ((Internetworldstats.com, 2016),(Telegraph.co.uk, 2016), (The Daily Dot, 2014)), the U.S. placed behind countries such as Russia, Romania, and Kuwait. But what about Mobile LTE? (Tech Insider, 2015)
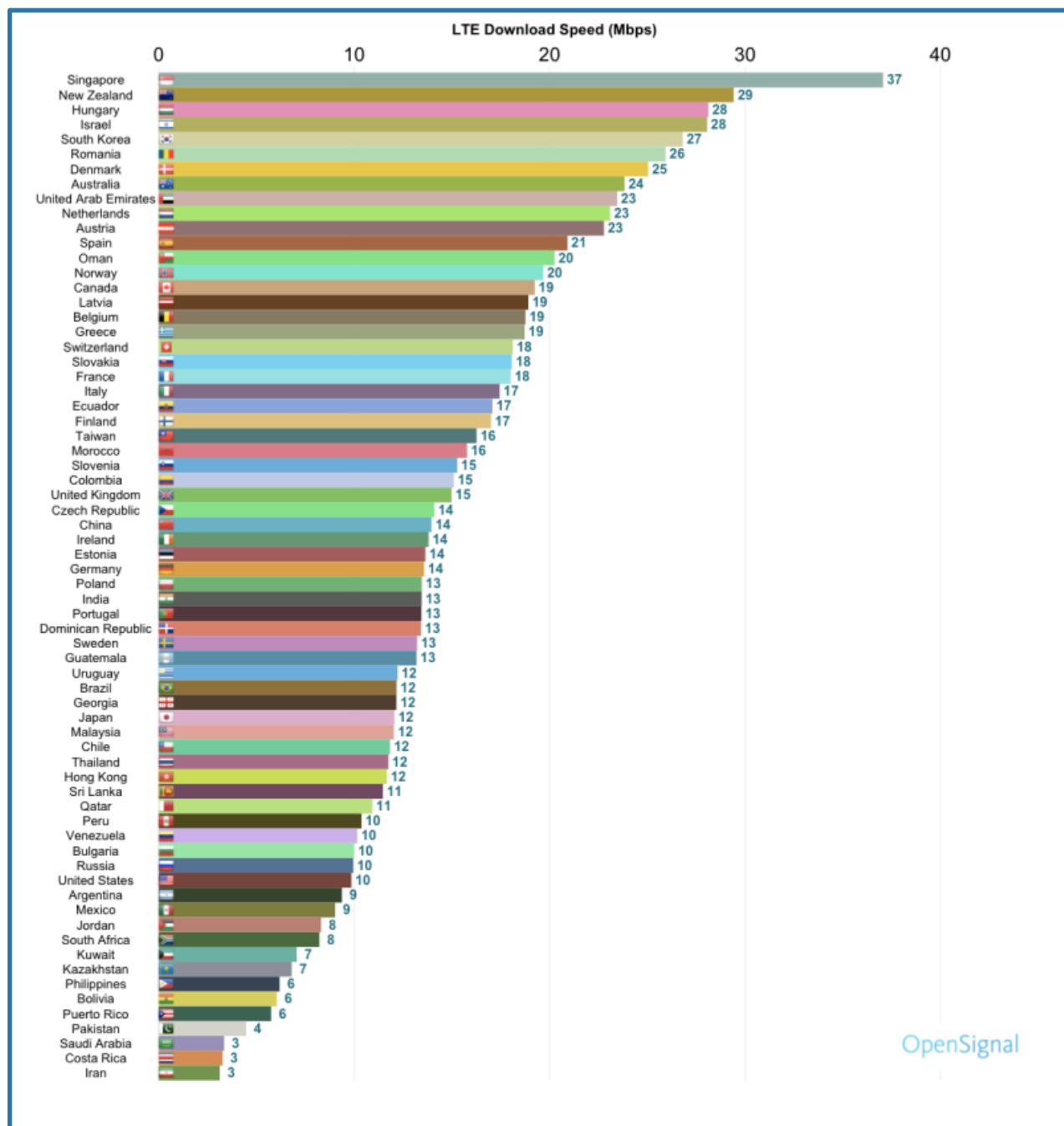
Fig 14 - Mobile 4G LTE World Speed Ranking (Bgr.com, 2016)

Even Mobile 4G LTE speeds are terrible compared to the rest of the world, with the U.S. ranked 55th.(Bgr.com, 2016)

Data Caps

Data caps are often implemented by ISPs, where data over a given threshold is charged a premium, or speeds are significantly reduced ('Throttled'). These caps are claimed by the ISPs to be necessary due to loads on the network by a small group of data intensive users. These caps ease the loads and help the ISPs maintain their quality of service. However, leaked documentation (Hothardware.com, 2015), small, regional ISPs refusal to implement data caps, and select ISP leadership claims all point to data caps being a nonessential factor to network congestion.
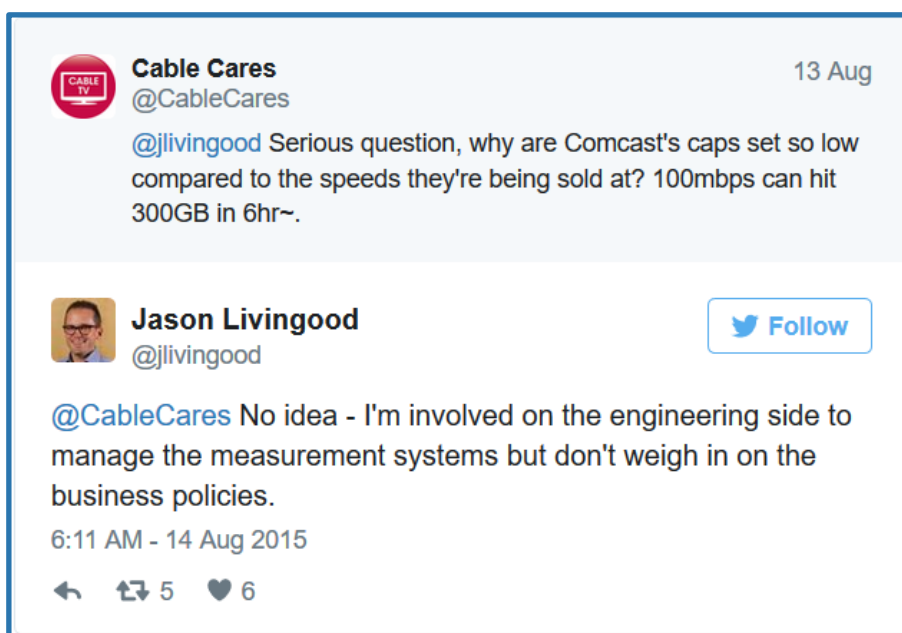

Fig 15 - Comcast VP Admits Ignorance of Data Caps (Hothardware.com, 2016)

These data caps affect the consumer so much that research conducted by the FCC revealed that customer complaints about data caps had increased to 7,904 in quarters 3 and 4 of 2015 versus 863 in quarters 1 and 2. A option for bypassing data caps exists for many of these large ISPs, but the consumer and content provider must be willing to pay, which violates a basic tenet of internet ethics which we cover next.

Net Neutrality

The Open Internet Order adopted by the FCC essentially bans ISPs from discriminating against certain types of traffic. However, this has been challenged heavily by the ISP lobby and can be overturned in the future. In the meantime, loopholes in net neutrality have been found. Dubbed

"Zero Rating", this is a practice where certain types of content traffic are exempt from data caps. Instead of throttling speeds to content heavy providers (think netflix), the ISP has content that is exempt from the data cap, that these content heavy providers can pay to allow their customers. (WIRED, 2016) Does it work? Yes. Netflix believes in Net Neutrality, but if they cannot deliver a good viewing experience to their customer, then their whole business is at risk. Therefore, they'll pay toll fees to access Comcast subscribers, and Comcast subscribers pay a fee to access content providers like netflix. They're essentially double dipping.
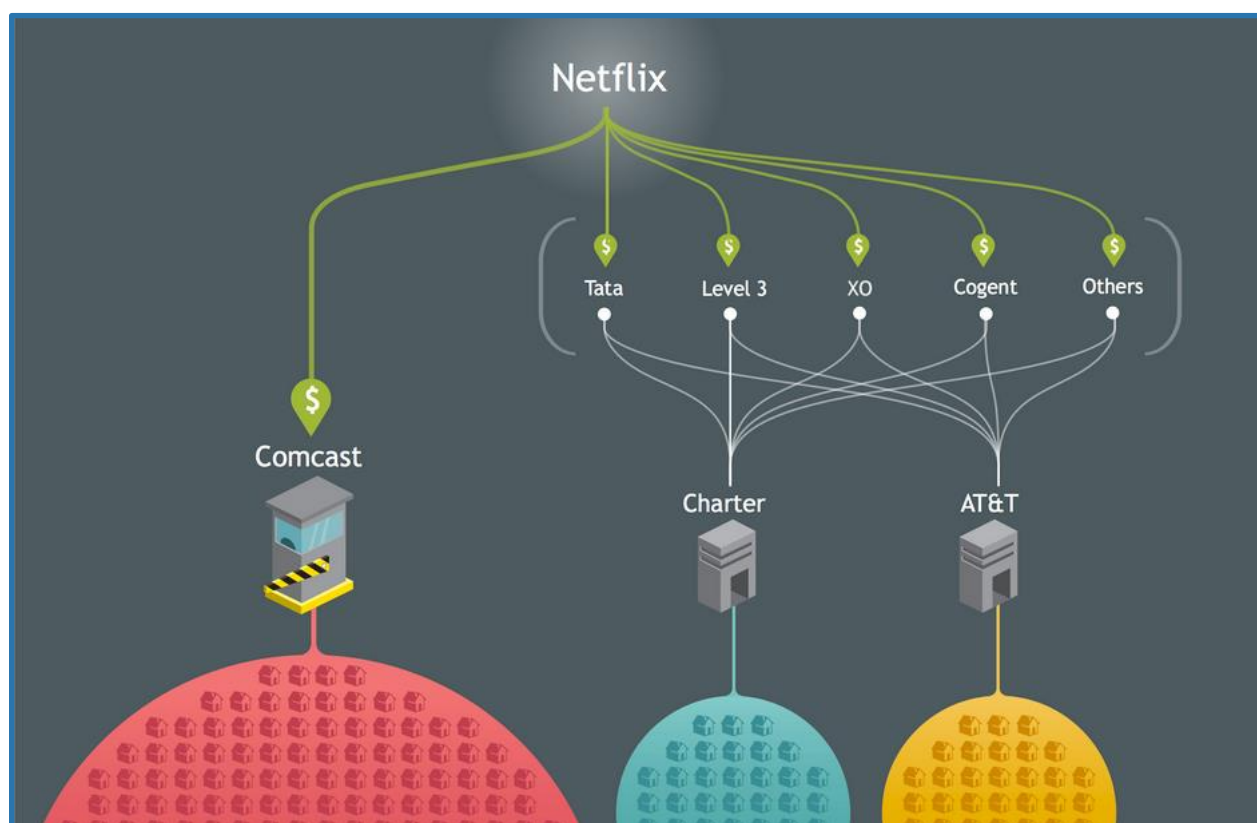

Fig 16 - Netflix payment for preference (Media.netflix.com. (2014)

Consumers may see increased costs or fees with their content providers because those providers have to pay for the ISP toll in order to reach their consumer. But Fees with the content providers can be justified, with the ISP however, many are not.

Fees

Fees of any kind to a consumer are painful. Especially when these fees are hidden, and in place to pad profits. These can take the form of high rental fees for shoddy equipment such as wireless routers or digital video recorders. (Craig, 2016) Many of these fees can be hard to identify and are phrased to appear as a mandatory cost of doing business under government regulation such as the Internet Cost Recovery Fee, when in fact these are basic expenses any ISP doing business must pay for. By appearing as a government required expense, the ISP effectively shifts consumer blame for the fee from themselves onto the government. In order to counteract this practice and increase fee transparency among ISPs, the FCC has proposed a consumer friendly service plan label much like a nutrition label for food manufacturers.

Broadband Facts

Fixed broadband consumer disclosure

Choose Your Service Data Plan for 50Mbps Service Tier	
Monthly charge for month-to-month plan	$60.00
Monthly charge for 2 year contract plan	$55.00
Click here for other pricing options including promotions and options bundled with other services, like cable television and wireless services.	

Other Charges and Terms	
Data included with monthly charge	300GB
Charges for additional data usage – each additional 50GB	$10.00
Optional modem or gateway lease – Customers may use their own modem or gateway; click here for our policy	$10.00/month
Other monthly fees	Not Applicable
One-time fees	
Activation fee	$50.00
Deposit	$50.00
Installation fee	$25.00

Fig 17 - FCC Proposed Internet Service Plan Label (DSL Reports, 2016)

Customer Service

In various customer service studies, the telecom providers consistently rank at the bottom with the major ISPs making up these companies.

Fig 18 - Internet/TV Service Industry Ranking (CNET, 2013)

Across 19 industries surveyed, Cable TV and Internet providers consistently ranked at the bottom. According to customer service reps, the process in order to rectify a problem at home is routed to a terrible automated attendant in order to cut costs on customer service overhead, and when trying to cancel, they intentionally want to piss off customers by routing you through different customers service reps, and lengthening the cancellation process so when you do finally cancel, you're so upset, you forget the early termination fee the 2nd rep mentioned.

Barriers to Entry

With the recent merger of the 2nd and 3rd largest major ISPs Charter and TWC (Time Warner Cable), ISP control and power over the industry continues to remain untested. This oligopoly has become such a problem, that there have been a handful of small startup and municipal ISP's developing. These startups and municipalities are building their own networks, but expansion has

been difficult with the ISP Lobby blocking attempts. Additionally, any organization that requires a network build needs to pay expensive fees to local governments in order to put wires on poles or under roads.

Municipalities and Startups

At least 20 states in the U.S. have some type of restrictions concerning municipalities building out their own network. This keeps a significant portion of the population under served without adequate access to subpar internet - or in many cases - any internet at all.
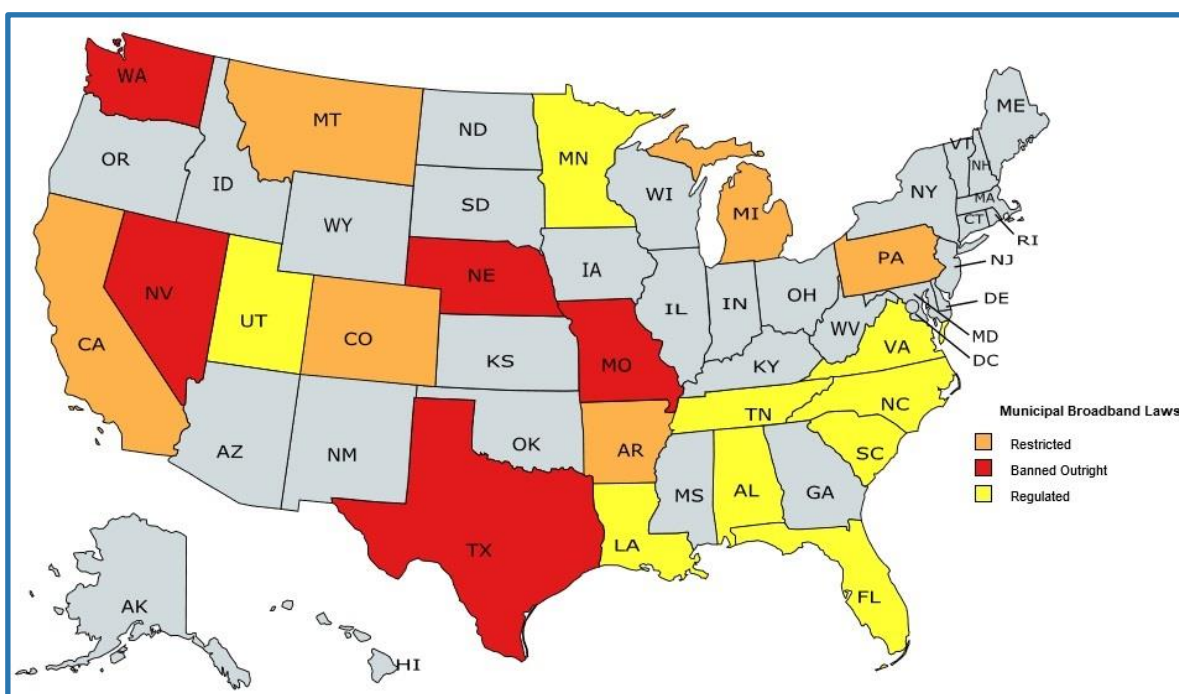
Fig 19 - Municipality Restrictions Nationwide (The Daily Dot, 2015)

To counter the ISP lobby, Amazon, Netflix, Google, Facebook, and many other technology companies have formed a group known as the "Internet Collective" representing their common interests - of which is to dismantle these restrictions on municipalities. (Consumerist, 2015) Federal government is also getting involved, with the FCC attempting to disrupt these restrictions to allow greater freedom to the municipalities. (Motherboard, 2016)

Fig 20 - Fiber/Cable Overbuild (Motherboard, 2014)

In the near term however, many municipalities are left with no options, or the big name ISPs. Some startups have attempted to address this gap by providing their own internet service, but are consistently met with difficult challenges:

- Frivolous law suits filed by ISPs

- Permits for building fiber

- Fiber buildout is expensive, and overbuild - that is laying a new network after the city has been built - adds even more to the expense (due to this, many startups target rural areas and have seen some moderate success).

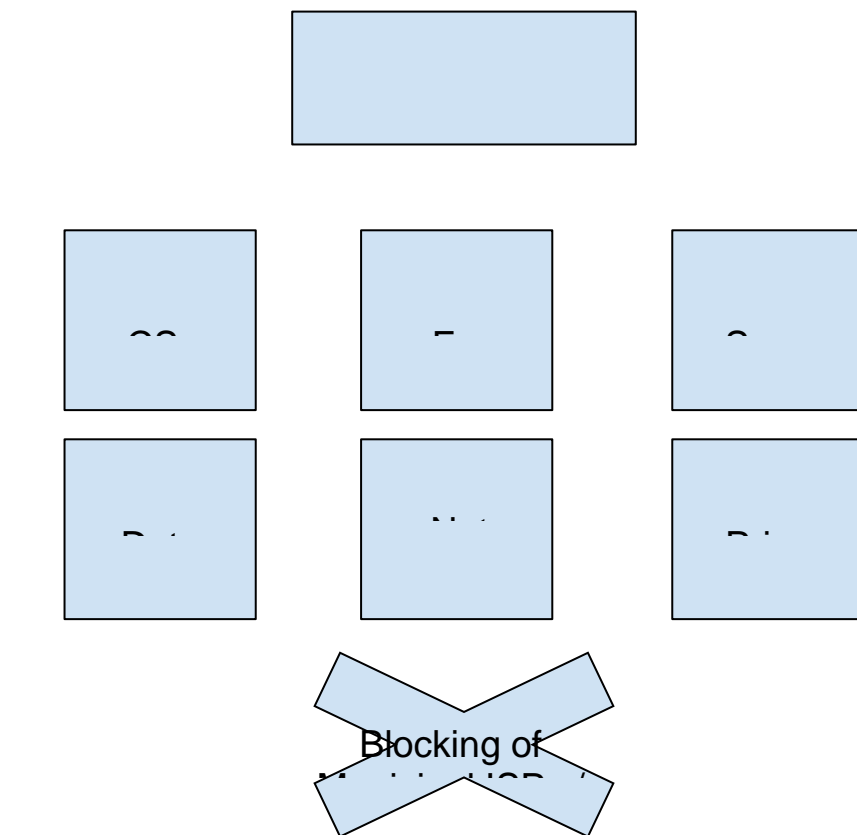- Converting customers from existing incumbents (Ars Technica, 2014)

Fig 21 - Problem Overview

Because of these restrictions, the battle over a better internet is being fought at the legislative level with municipalities and startups. So where does our team fit in? (Ars Technica, 2014)(CNET, 2013).

Solution

Simply put - The UNSP is considered ideal to compete with incumbent ISPs in that the typical restrictions on municipalities and startups do not apply to the UNSP. The UNSP will station keep and provide broadband services in the form of WIMAX (Worldwide Interoperability for Microwave Access) or LTE (Long Term Evolution) depending on mission requirements and customer need. This market is suitable to the UNSP as the MVP can be as simple as a very cheap high altitude balloon with a rudimentary communications payload able to provide access to underserved communities. This removes the need for expensive permit and infrastructure costs associated

with fiber buildout and overbuild typically barring entry to this market. In theory, we have the ability to provide internet without the limitations of terrestrial infrastructure which makes us green, and without the cost, noise, and latency issues of a satellite.

Market Size and Revenue Model

Total Addressable Market (TAM) - 7.4 Billion people worldwide

Serviceable Available Market (SAM) - 323,785,881 (2) (U.S. market)

Serviceable Obtainable Market (SOM) - 124,000,000 (~38% of U.S. Market)

Our initial model appears as a tariff system to users, where they pay for the time they use. Overtime as the UNSP would expand to other communities, the model would transition into a hybridized, freemium/ad supported model where the tariff system is in place, but users are also able to access the network for free with ads. The process would be extremely simple: when users connect to our wifi, they arrive at a landing page similar to one you would see at starbucks. This page will have quality ads ranging from large companies to local businesses. These users would be able to choose their ad experience once they register and if they'd like - for a fee - they can determine whether they would like to remove ads completely through the tariff system. This model is proven as Facebook and Google are high traffic websites that make the largest chunk of their revenue from targeted ads.

This ease of access would eliminate lengthy sign ups or contracts, emphasizing fast, easy, and cheap. Data caps, throttling, 'zero rating', and hidden fees would be non existent as this would violate our ethics and goal of providing excellent customer service.

Competitors

This new model is not without competitors however. Below we can see several of the players we are likely to contend with:

OneWeb Satellite Constellation

- 700 Satellites expected to provide global internet broadband service to individual consumers as early as 2019. Expected to require $3 Billion in Capital by the time constellation becomes operational.

Google

- Project Loon

- Project Titan (AKA Skybender)

Facebook

- Aquilla

SpaceX

- SpaceX 4000 Satellite Constellation by 2020

Samsung

- Proposed 4,600 Satellite Constellation, but nothing further seen.

All Incumbent ISPs

- Cox, Google Fiber, Verizon, AT&T, TWC

Others

- O3B

- Starry - Millimeter wave internet startup

Our closest competitors are considered to be Google and Facebook as their high altitude platforms - although significantly different in design and capability - are specifically tailored to internet delivery missions. The two giants have fantastic teams behind their current HAP programs, and a large pool of resources to back these technically challenging ventures. Despite this however, we believe we can remain a competitor in the market due to two primary reasons.

The first is that we maintain a competitive advantage due to the inherent abilities in UNSP. In other words, our differentiator is design. Although Google and Facebook are able to field their platforms for internet delivery, their platforms are not assessed to be easily adaptable to missions

beyond this. This allows other markets for cash flow effectively diversifying the "profit portfolio" of the UNSP.

The other reason is based on an understanding of their goals. We assess these two giants will support us if we can prove we are reliable and show traction. How? Google and Facebook's building of HAPs and Constellations to provide internet is centered on the fundamental idea that the more people who have internet, the more people can access Google and Facebook which equates to revenue. So the actual method of internet delivery does not matter, as long as that delivery leads to user growth.

This is supported by the following excerpt from online magazine *Motherboard* -

"It's been six years since Google announced it would lay a fiber network to compete with cable providers and telephone companies. Although it's now in only four markets, competitors are lowering rates and building faster lines to keep customers from defecting to the technology giant. Because Google needs consumers to have robust Internet speed in order to sell more expensive ads on its search engine, that may be what it had in mind all along."(Motherboard, 2016)

As incumbent ISPs begin to increase their offerings in response to Google Fiber rollout, Google Fiber no longer has to be competitive. This signals that Google Fiber was intended as a catalyst for ISP service improvement, with revenue generation being a secondary objective. Additionally, Google's investment into the SpaceX constellation runs in direct competition with Google Fiber (Dunmore.com, n.d.). Understanding the motivations of your competitors can reveal a solution and partnership that benefits both parties. If the above is true, our business model complements theirs. Our success is theirs, and their success is ours. We allow more users online and from this, other providers of online content (Ex. - Netflix) would likely provide support as we have no restrictions of bandwidth, data caps, and best of all, neutrality in content.

A New Direction: Raven Bold

(July / August)

At the conclusion of the presentation detailing our new direction into the communications market, I received generally positive feedback from the space portal team. A significant issue presented itself however: where do we begin? It was identified that a gap existed between where we were, and the roll out of our MVP. Funding and establishing traction were considered the primary gaps, while having a better understanding of the customer need served as a secondary gap which I would find later to be critical. With these gaps in mind, the primary space portal mentors - Dan and Bruce - introduced me to a preliminary step which would bridge the gap between where we were and where we needed to be.

Raven Bold

The concept was simple - our team for the time being functions as an internet consulting firm to underserved communities. We provide free, and fee for service assessments and reports to the communities which detail internet service quality in their region. Our primary customers would be either counties or municipalities. The objective was to approach these underserved communities and offer them the free assessment, then upon delivery, offer an additional in-depth report for a fee. During this process, the opportunity to take part in a pilot project (UNSP MVP) would be available to the communities that participate in the study. The pilot project would commence once the MVP was fully prepared, we had enough demand, and we were at the appropriate funding level to continue. This preliminary step served multiple purposes:

1. We understood our market and the customer need better.
2. We built relationships with our customers.
3. We establish traction through our fee for service reports.

Having an understanding of the market and customer proves invaluable as we know the pain points for our customers and the best way to provide our service. Building relationships with our

customers would provide us a competitive advantage as it would differentiate us from our competitors. Lastly, by showing cash flow and growth, we establish traction which is valuable in the eyes of potential funders as it shows a real need exists.

This was a excellent way of moving forward as it required little to no funding (self funded) to get started as our primary product was informational. However, I was already past the halfway point of my internship, with roughly six weeks left on paper. In reality, I had only three to four effective weeks remaining to establish this new step. The other two weeks being allocated to the Space Coast trip to LA visiting SpaceX, JPL, Virgin Galactic, Spire, Planet, and the other being the last week of the internship focused on this report.

The plan to move forward after consulting my team (via regular Skype meetings) and the mentors was to reach out to three underserved counties in California closest to NASA Ames in order to have a face to face meeting after providing a sample report of our work. Three were chosen as this was assessed to be a manageable number to provide reports for. A few requisite steps were needed before we could initiate contact with the counties:

1. A draft assessment
2. A website
3. A draft first contact email

To represent ourselves as professional and adept in our pursuit, all of the above needed to be of high quality. This was a tall order in the remaining time, but with the help of my team, we were able to develop a new brand.

The Website

This preliminary step was considered a significant departure from our original image even if our goals and objective remained intact. Therefore it was necessary to create a new brand around this venture. This helped delineate the long term objective company which was Unity, and the short term objective of providing internet. I had personally owned several domain names, one of which used to be a startup fashion brand called Raven Bold. Being unused, I felt it was an appropriate fit for our venture. I also had domain hosting for various websites I owned, which helped cut the time to begin work on the site. Having a very rudimentary knowledge of wordpress (web software used for creating web pages), I decided to select it as my primary software for setting up the website.
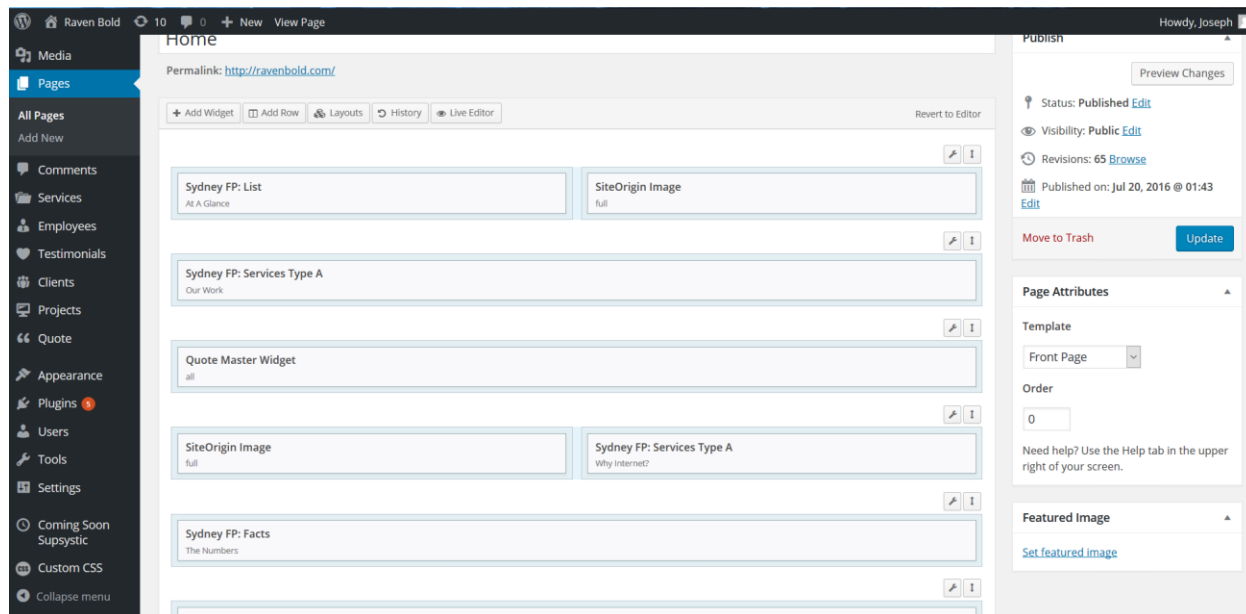
Fig. 23 - A screenshot of the Raven Bold Wordpress Dashboard (UNSP Team, 2016)
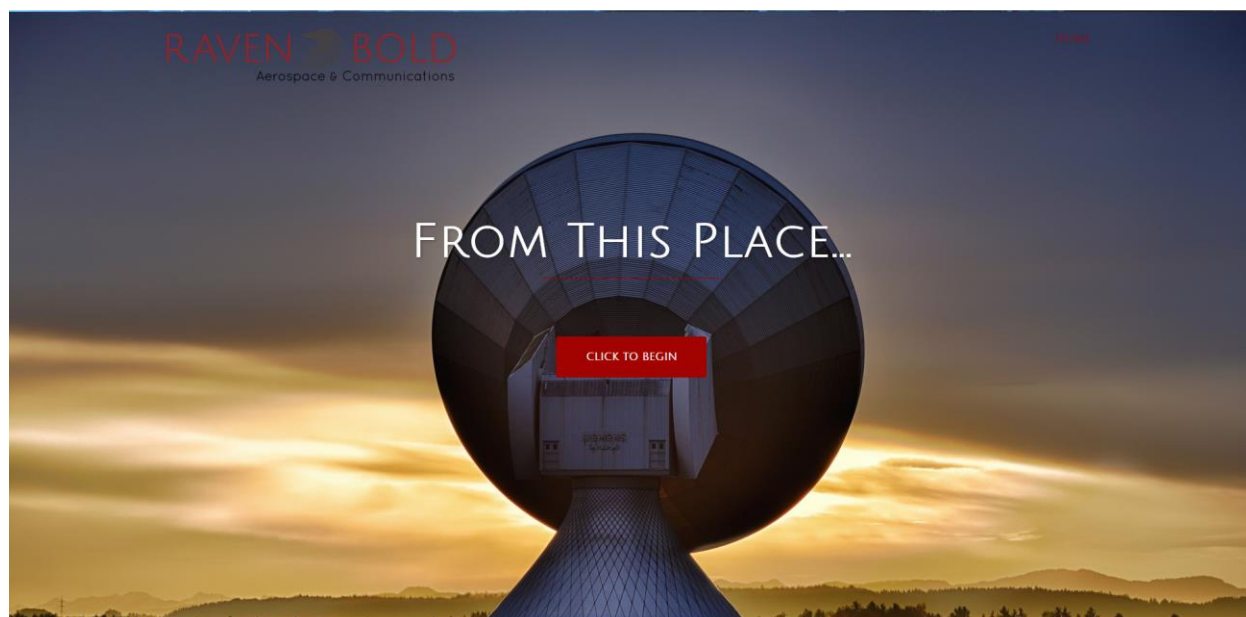

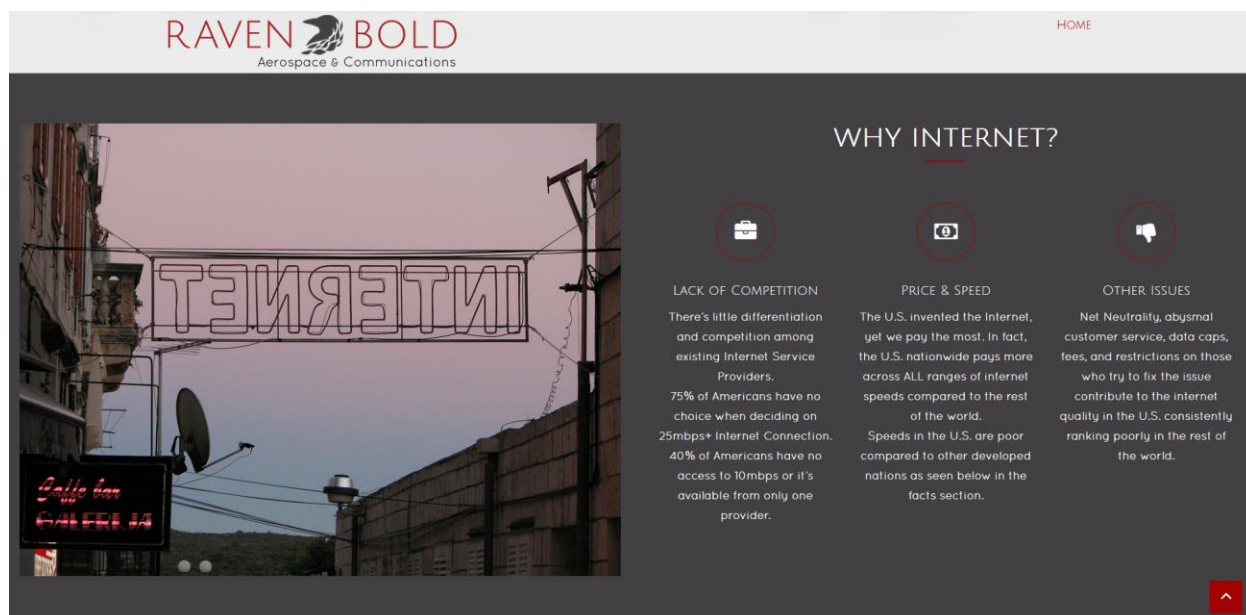Fig. 24 - Screenshot of Ravenbold.com (UNSP Team, 2016)

Fig. 25 - Screenshot of Ravenbold.com (UNSP Team, 2016)

Although I had a vague familiarity with wordpress, I was using a new template, and had no coding skills to customize the size quickly. Therefore a significant amount of time was spent doing research to understand what I needed to do in order to manipulate the website to fit our needs.

Despite the difficulties, the website produced exceeded expectations, with the above screenshots depicting the final website that was developed. Ravenbold.com serves as a supplement to the counties that would want to know more about our work beyond the introductory email.

The Email

The final email, which went through several iterations, can be seen below in an abridged format:

Hello,

My name is Joseph Christensen and I am a graduate student and research associate at the NASA Ames, Space Portal Office.

Main Point:

Our small team is developing a commercial venture focused on a novel technology for delivering internet. Mariposa County has been assessed to be an ideal candidate for a closed test, where we will provide our broadband assessment service free in exchange for feedback, and for the county to agree to be a reference.

Background:

Our goal is to provide better internet access and quality to underserved areas and communities. The current internet service landscape suffers from a lack of competition resulting in higher than average pricing, subpar speed, and inferior customer service. This problem is exacerbated for small communities, and grows more difficult as legislation is passed that restricts or outright bans municipalities from resolving these issues on their own. This has led our team to explore a new type of internet delivery technology which has a variety of applications we're excited to explore.

Who we are:

We're an international team with a variety of backgrounds ranging from aerospace engineering to intelligence analysis. We are also advised by a stellar group of seasoned veterans at NASA, ESA, and the International Space University in France in which we attend. This new venture has a focused team ready to solve the ISP challenges Mariposa county faces today.

As the time remaining for our internship is relatively short, please respond by August 12th to further discuss. If there is someone else you believe we should speak with, please advise.

Thank you for your time!

My Best,

Joseph Christensen

Joseph@ravenbold.com

Joseph.S.Christensen@nasa.gov

The Assessment

Lastly, the report we would provide needed to be drafted in order to make sure the team understood the contents. We picked Inyo County as an example case since they did not fall into the top three counties we were targeting. We set five primary categories we believe would be most useful to the counties:

1. Service Providers - This includes where ISPs operate, coverage, and availability.
2. Customer Service - Satisfaction amongst the population within the county.
3. Pricing - Pricing scheme by provider and plan, but also in relation to median income in the county.

4. Speed - High, Low, and Average speeds in the county, and availability of the various speed tiers, especially broadband.
5. Technology Available - This includes the deployment situation of Wireless, Mobile, Wired, and Fiber options within the region.

Within these categories, metrics were developed for two subcategories only our team used: Basic and Custom. Basic metrics involved measures such as average speed in the county, population with/without access to broadband, etc. Custom measures were metrics we developed that through analysis of the basic measures, we could generate enhanced metrics that were relevant to a county's interests such as customer desire for a given technology or percentage of a household's funds allocated to current internet plans in relation to median income.

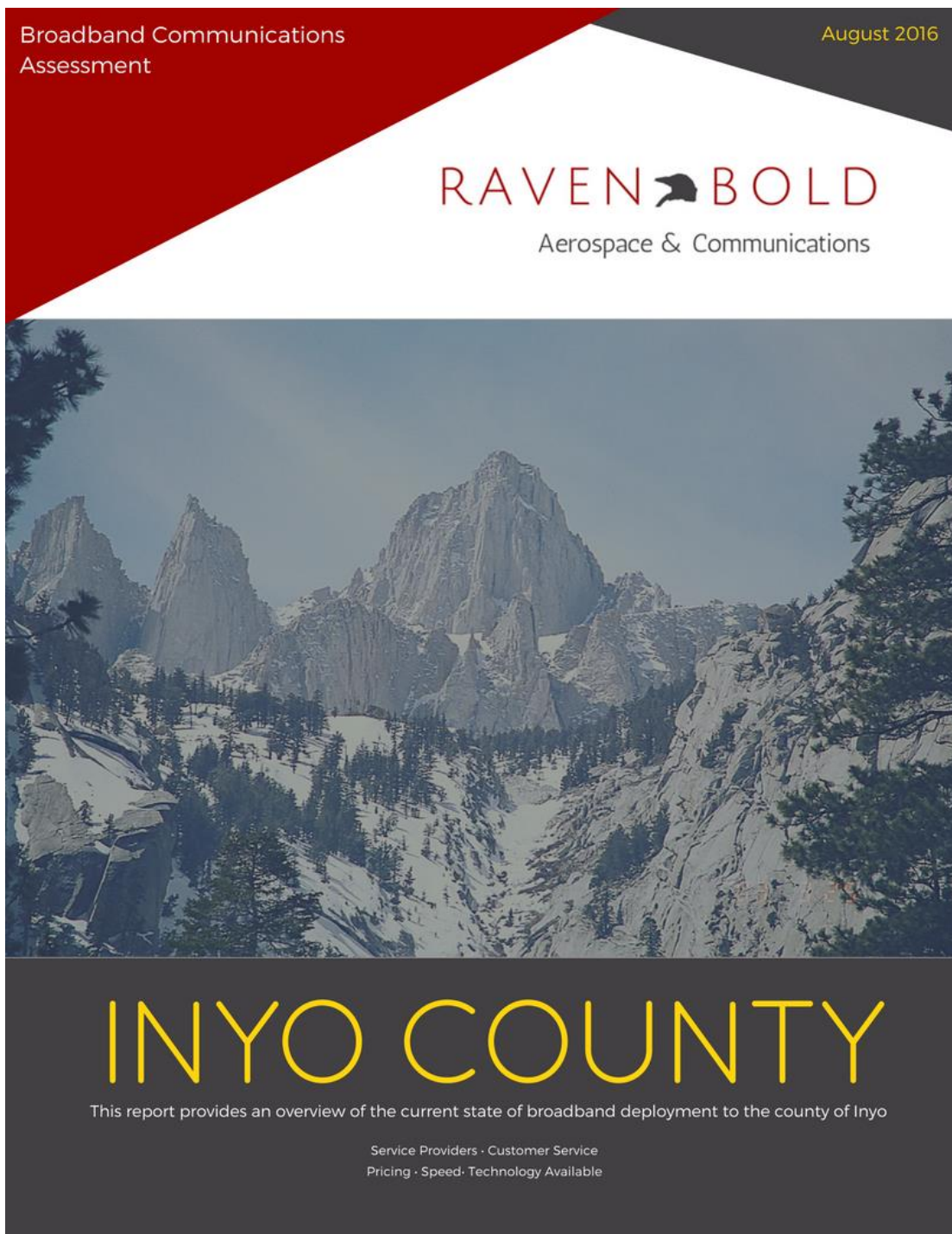We can see sample pages of a rough draft assessment below.

Fig. 26 - Assessment Cover Page (UNSP Team, 2016)

Fig. 27 - Service Providers Section (UNSP Team, 2016)

Fig. 28 - Service Providers Section (UNSP Team, 2016)

Service Providers

Contents

Internet Service Providers (ISPs) provide internet connectivity to various customers from residential addresses to large businesses. ISPs range from Wireless Internet Service Providers (WISPS) typically seen in rural areas, to the larger Cable and Fiber providers such as AT&T or Verizon. In this section, we gain some insight into the ISPs in Inyo.

The map below depicts the Inyo County. The table to the left shows the top 80% of the population availability. Provider deployment has increased over the last 10 years, however this trend reveals that Inyo does not receive faster deployment until the technology has become ubiquitous, and that the deployment does not significantly increase access.

Provider	Location	Value
AT&T	Bishop	0.9720
Dish	Null	
Earthlink	Null	
Exede	Null	
Frontier	Bishop	0.9140
HughesNet	Bishop	1.0000
Suddenlink	Bishop	0.8520
Verizon	Bishop	0.9710
WildBlue	Null	

BCA - Inyo County
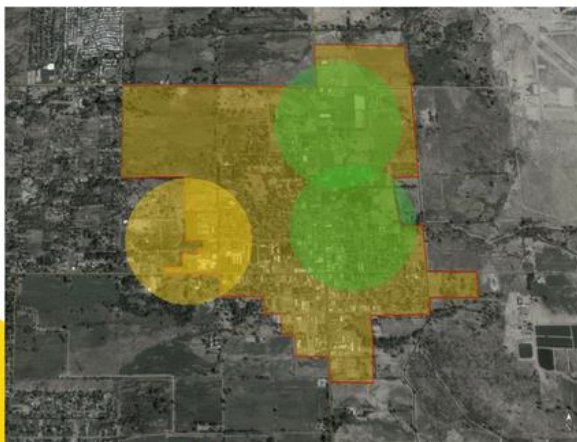
02.

Fig. 29 - Service Providers Section (UNSP Team, 2016)

Fig. 30 - Annex collating remainder of data (UNSP Team, 2016)

The Latest

After an arduous process, the assessment, website, and emails were finished and launched on August 4th. The three counties we targeted were Alpine, Mariposa, and Mono counties in eastern California known for their mountainous and desert terrain. Due to the sparse populations in these areas, their proximity to the bay area and silicon valley, and their internet service provider quality, these regions were assessed to be the most viable for first contact for our initial test. Since then, we have established contact and are moving forward in cooperating with Mono county, while the other two counties will be recontacted in different departments.

Reflection & Going Forward

My time at NASA Ames space portal was one of the most rewarding learning experiences I've had with not only my work on Unity/UNSP/Raven Bold, but other engagements. A significant portion of my activity was allocated to meetings, events, and side projects. From all of these experiences, I was able to extrapolate several lessons.

On The Side

- **Singularity University (SU)**: Several events attended such as a talk given by SU/ISU Co-founder Peter Diamandis and a 'Mixer'.
- **NASA Ames Events:** NASA had several events on and off the research campus such as the Starburst Accelerator pitches, Frontier Development Lab Presentation, and The NASA Summer Series of lectures.
- **ISU Related Activities:** Mostly organized visits to space related entities. On Campus, a few visits included Made In Space, and Breakthrough Foundation. We also went on a NASA Ames led "Space Coast Trip" involving a trip to San Francisco to visit Spire and Planet, and a trip to LA to visit JPL, Virgin Galactic, and SpaceX.
- **LCDR Svec Project:** During the latter half of my internship, I became involved with a project for the Naval Partnerships office for LCDR Svec where I began volunteering some of my time. This involved creating infographics and interactive visualizations to convey related subjects and departments between the Naval Postgraduate School and NASA Ames. This was interesting as one of the first tasks was to create a treemap which I elected to make interactive. This required some coding in Javascript which I had no prior

experience in - Javascript or coding in general. However, I was able to create a rudimentary but interactive tree map with nested programs within various departments. This is a project that will likely extend beyond my internship and ISU graduation.
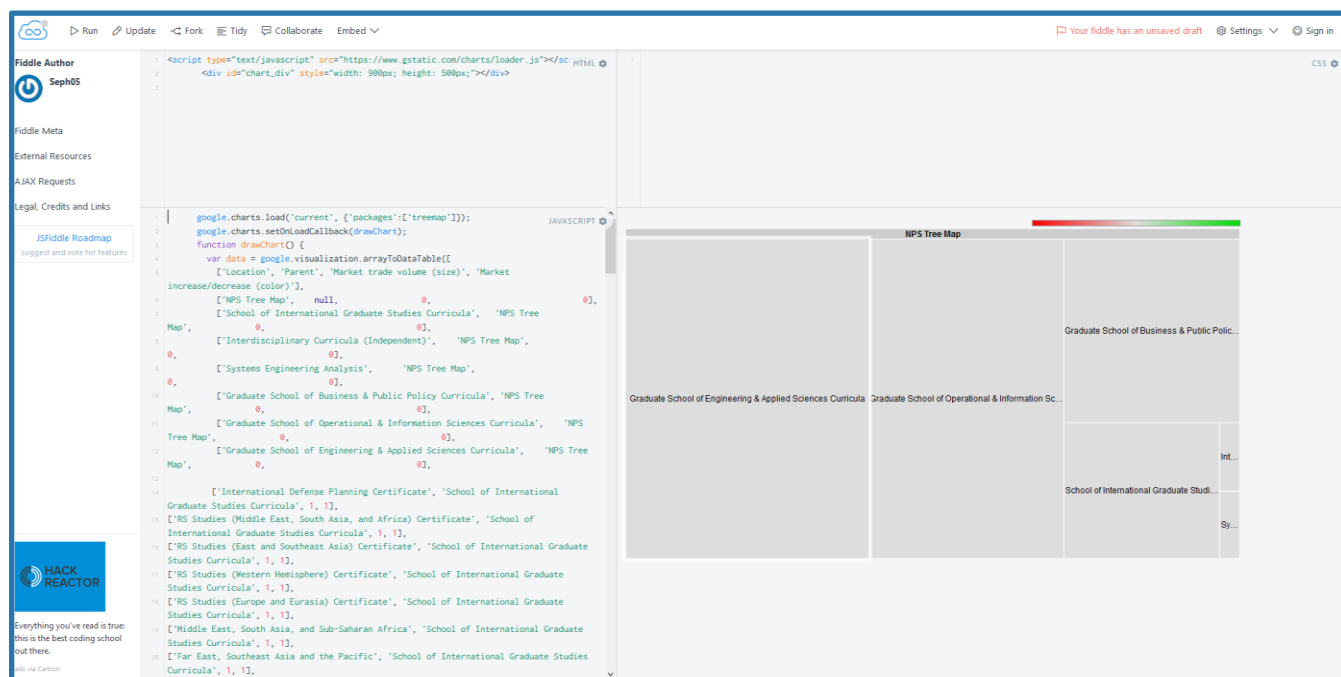
Fig. 31 - Treemap for LCDR Svec (UNSP Team, 2016)

Lessons Learned

- No one cares about seeing my project succeed as much as me.
- Many meetings can be avoided if the organizer asks themselves "Is this meeting necessary because there is no easier way to continue progress? If so, is everyone who will participate essential to this discussion?" Most of the time the answer is no.
- Some obstacles are time based, and just require re-engagement at a later date.
- Identify the smallest possible way of progressing, and continue from there.
- The best objective at a networking event isn't to approach the highest net worth/most influential person in the room (They are typically swamped and have their defenses up because of this). It also isn't to shake hands and pitch to everyone in the room hoping you'll get lucky. The wisest objective should be to make at least one meaningful connection with someone else. If you can do that, you've succeeded.

- It's valuable to say yes and show up as often as possible. This typically should happen earlier when one is entering a new environment looking for opportunities. However, it's just as important to say no and guard your time. This prevents burnout due to over engagement and allows one to committ to deep work (blocks of 3+ hours of focused work). Knowing which stage you are at and what is worth saying yes to is the tricky part.

Conclusion

My final presentation was given on 17AUG16 at space portal summarizing the second half of the internship. Overall, the progress made was a significant success given the time constraint of the internship and the multitude of meetings and other activities unrelated to the furtherance of the project. After reflectance of what had been accomplished over the year, there are still gaps in knowledge and obstacles that stand in the way of ultimate success of the UNSP. However, before the start of the internship, it was unknown how to reach our goal of providing the UNSP as a service beyond the ISU environment. We now have mentorship and a goal that requires hard work, but the path is known. My objective at this internship was to develop a new way forward for the project, and the team, and despite the setbacks throughout the year, I believe I accomplished this. I am excited to graduate, but also grateful to have participated in such a unique experience at ISU and NASA. Thanks to the efforts of those that have helped and guided me along this uncommon road, I expect to see everyday people gazing down at the Earth and up to the stars from Near Space in the not so distant future.

"The impediment to action advances action. What stands in the way, becomes the way."

- Marcus Aurelius

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