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nternship Report submitted to the International Space University in partial fulfilment of the requirements of the M.Sc. Degree in Space Studies

August 2015

ASSESSING UAS FLIGHT TESTING AND ITS IMPORTANCE FOR BEYOND-LINE-OF-SIGHT UAS CONTROL IN COOPERATION WITH PARTNERING ORGANIZATIONS

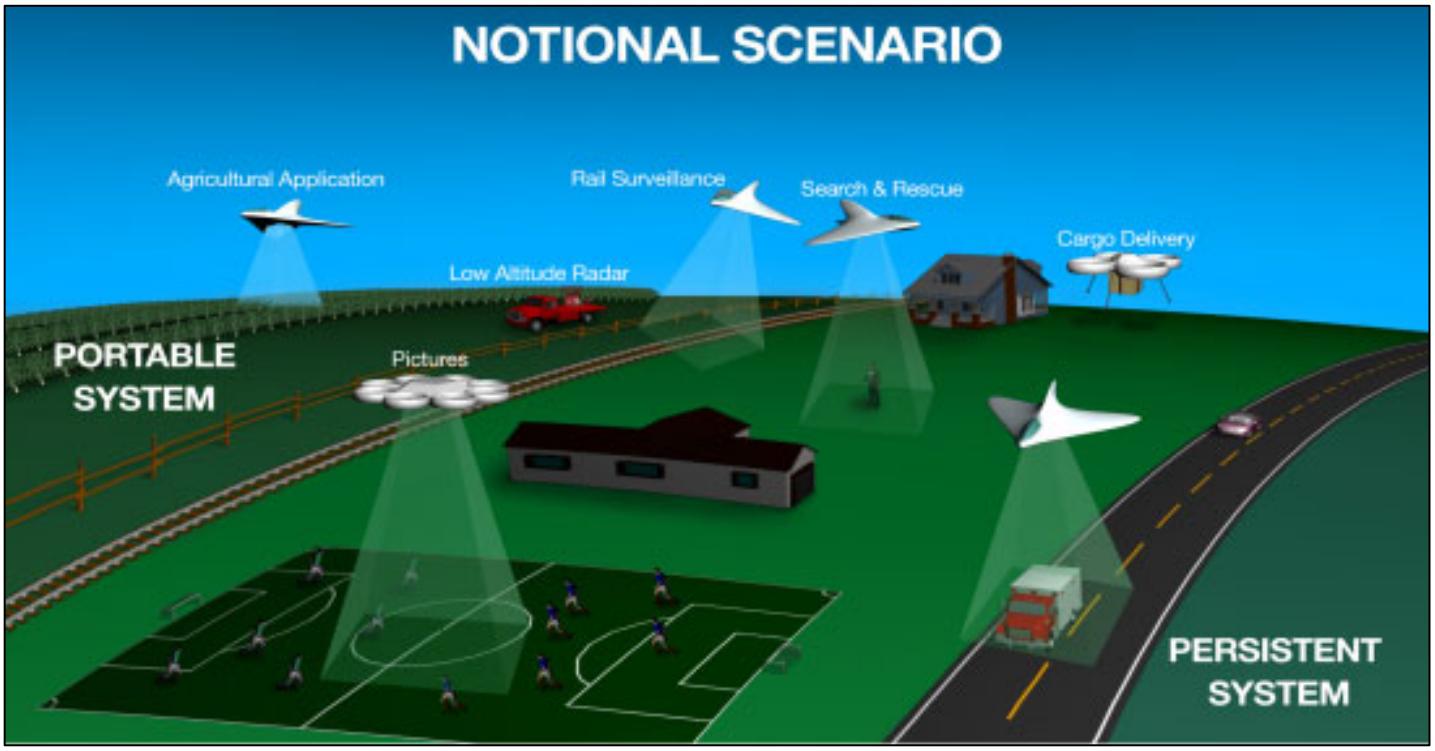

Photo Credit: NASA

Daphne de Jong – under supervision of mr. Junjiro Nakahara

ASSESSING UAS FLIGHT TESTING AND ITS IMPORTANCE FOR BLOS UAS CONTROL IN COOPERATION WITH PARTNERING ORGANIZATIONS

Daphne de Jong

Internship Report submitted to the International Space University in partial fulfilment of the requirements of the M.Sc. Degree in Space Studies

August 2015

Internship Mentor: **Mr. Terrence Pagaduan**
Host Institution: **NASA Ames research Center, Mountain View, CA, United States**
ISU Academic Advisor: **Mr. Junjiro Nakahara / Prof. Chris Welch**

Master of Space Studies 2015
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2. Partnerships
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Abstract

From the 1st of June until the 21st of August, the internship has been conducted at NASA Ames Research Center as part of the Master of Space Studies at the International Space University. The main activities consisted of doing research on UAV flight-testing and the assessing of safety with respect to Beyond-Line-Of-Sight operations.

Further activities consisted of accommodating international partners and potential partners at the NASA Ames site, in order to identify mutual interest and future collaboration.

Besides those activities, the report describes the planning process of the ISU Space Coast Trip to 10 different space related companies on the west-coast of California.

Key words: UAS, UAV, BLOS, Ames, ISU Trip

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Abbreviations

ARC – Ames Research Center
BLOS – Beyond-Line-Of-Sight
CIFER – Comprehensive Identification from Frequency Responses
FAA – Federal Aviation Authority
ISU – International Space University
LCROSS – Lunar CRater Observation and Sensing Satellite
LEO – Low Earth Orbit
LOS – Line of Sight
NACA – National Advisory Committee for Aeronautics
NASA – National Aeronautics and Space Administration
NOAA – National Oceanic and Atmospheric Administration
NWS – National Weather Service
OIIR – International and Interagency Relations
PID – Proportional, Integral, Derivative
SOFIA – Stratospheric Observatory for Infrared Astronomy
UAS – Unmanned Aircraft Systems
UAV – Unmanned Aerial Vehicle
UHF – Ultra High Frequency
UTM – UAS Traffic Management
VTOL – Vertical Take-Off and Landing
WAAS – Wide Area Augmentation System

1. Introduction

From the 1st of June until the 21st of August, the internship has been conducted at NASA Ames Research Center as part of the Master of Space Studies at the International Space University. This report will describe Ames as a host institute, the specific position and the main activities during the internship. An overall structure will be provided.

1.1 NASA Ames Research Center

NASA Ames Research Center has a long lasting relationship with ISU, especially with respect to internship opportunities and is lead by the current center director Dr. Eugene Tu (NASA, 2015)

Based in the heart of Silicon Valley, Ames was established on December 20, 1939, as part of the National Advisory Committee for Aeronautics (NACA), before the National Aeronautics and Space Administration (NASA) was established in 1958. Named after physicist and founding member of the NACA Joseph Sweetman Ames and (NASA, 2015) as one of the ten NASA centers, Ames specializes in Research & Development.

Originally, Ames was founded to conduct testing on rotorcraft in its large wind tunnel of 80 by 120 feet. Now, there is a big variety in research topics and Ames has an important role within current spaceflight missions (NASA, 2015)

Key current missions include Kepler, the Stratospheric Observatory for Infrared Astronomy (SOFIA), the Lunar CRater Observation and Sensing Satellite (LCROSS), the UAS Traffic Management project, and the Orion crew exploration mission. Other activities include work on small satellites, robotic exploration, astrobiology, and artificial intelligence.

1.2 The UTM Project

NASA Ames Research Center (ARC) is working on Unmanned Aerial System (UAS) and UAS Traffic Management (UTM) research and development with the goal to enable safe low altitude (AGL 2000 feet and below) operations in class G airspace within the dynamic regulation network, collaborating with the Federal Aviation Authority (FAA). The final outcome will be a UTM system and demonstration of low-altitude UAV operations for a national benefit (NASA, 2015).

Collaborating parties of NASA Ames will work with the results, including the FAA, the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), UAS manufacturers, researchers, and policy makers. The possible applications include good delivery, infrastructure surveillance, and surface monitoring.

UTM capabilities will be tested for weather integration, geo-fencing, collision-and-avoid management, contingency management, and surveillance. Policy makers will work together with NASA Ames to improve the safety of the UAS environment, adapting to changes along the way.

The UTM project is divided in four different planning stages, which are as follow:

- Stage one: Establishing the airspace design, taking trajectories into account
- Stage two: Dynamic adjustments and contingency management
- Stage three: Separation and collision management
- Stage four: Manage large-scale contingencies
  (NASA, 2015)

An overview of the different builds and a timeline can be found below in Figure 1.

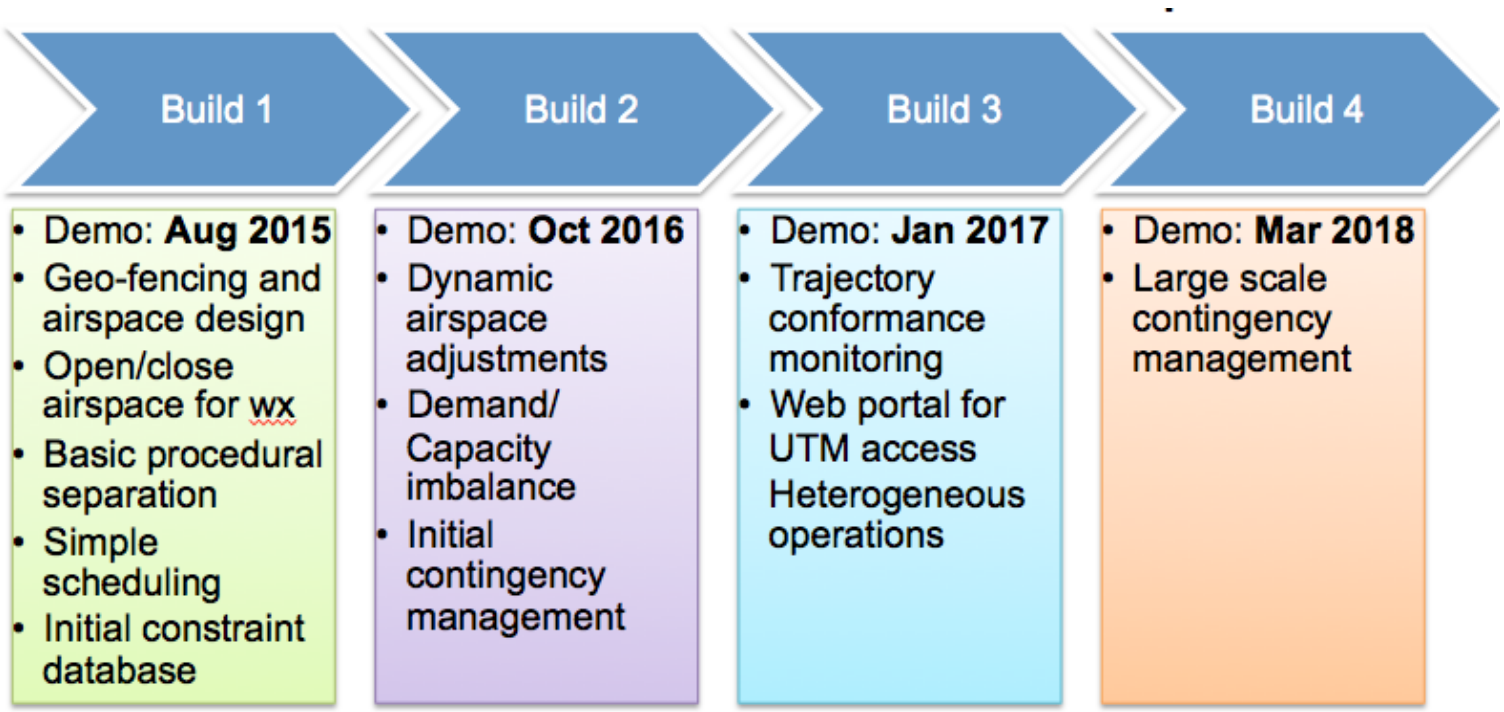


Figure 1: Overview of UTM Builds (NASA, 2015)

Clear is the gradual implementation of the combined software systems and shifting from basic procedural separation to large-scale contingency management in March 2018.

An overview of the current and future vision on developments within the UTM project, can be seen below in Figure 2.

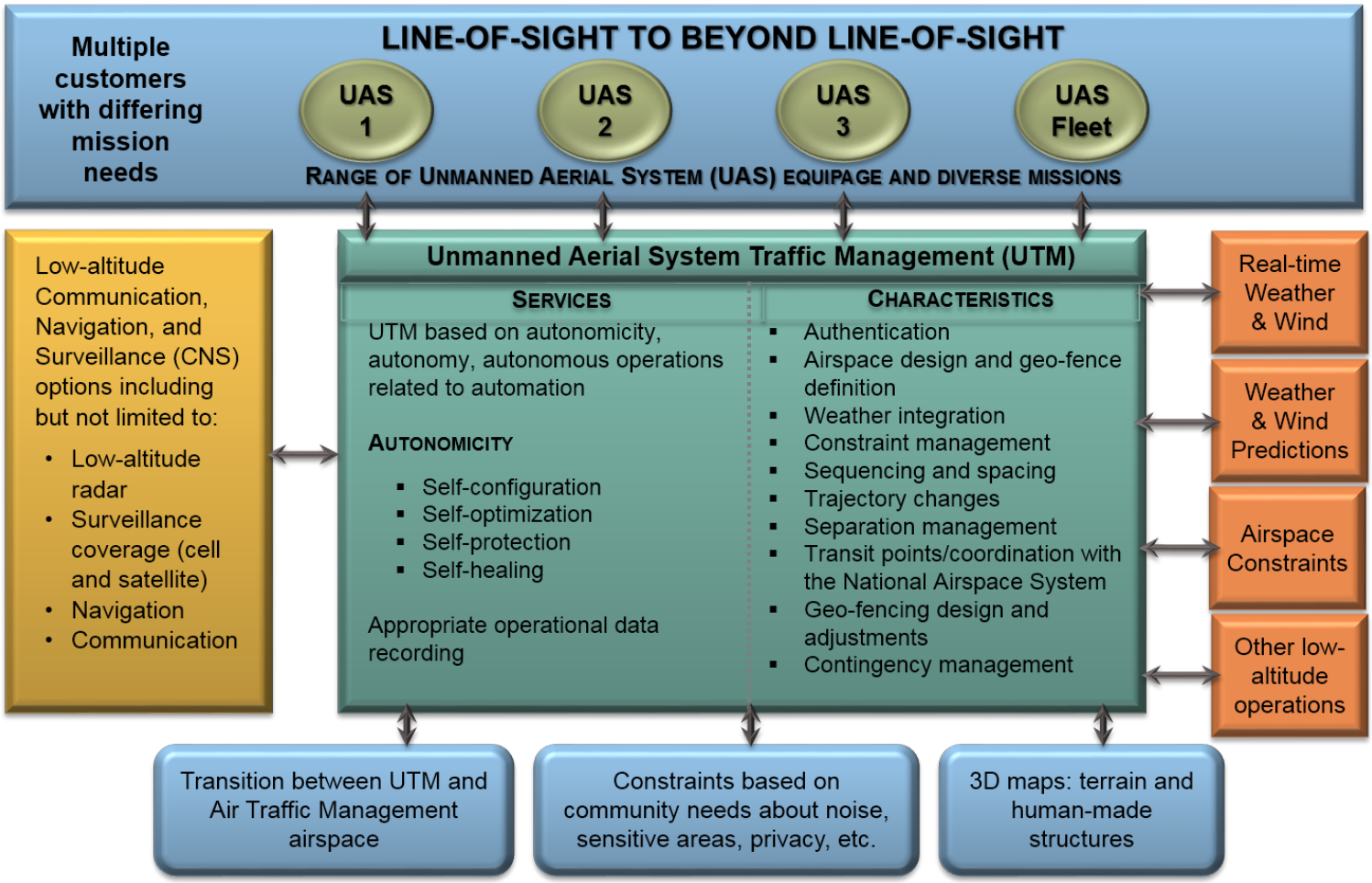


Figure 2: Move to BLOS operations (NASA, 2015)

In order to make the system as safe as possible, different scenario's will need to be tested, under which a loss of signal of the UAS. This report will describe the research that has been conducted during this internship, under which several scenarios, and will cover possible complications solutions.

1.3 Partnerships

International Partnerships at NASA Ames works close with the Office of International and Interagency Relations (OIIR) in order to support cooperation with partners worldwide. Technical and non-technical agreements exist with space agencies, universities, and technology companies. The used mechanism for NASA's partnerships with global entities is the International Space Act Agreement, of which there are 47 active ones solely at NASA Ames.
As part of new developments within NASA Ames, the Partnerships office will play a significant role in future collaborations as well.

1.4 The UTM project and Partnerships

Partnerships plays a significant role in the UTM project, considering that a platform will be created to support operations from different companies with respect to the UAS flying in the same aerospace. In order to enable this to happen, the operating methods of all participating partners will need to be able to work with the UTM system. Companies such as Amazon, Google, Airware and Airmap, are involved in the partnership in order to create the most complete product.

1.5 Internship description

The activities during the internship included of several different projects, as stated below:

The main activities were involving both code BL, International Partnerships, and Code A, Aeronautics, at NASA Ames Research Center, and were focused on the UTM Project. Besides researching loss of signal consequences and solutions, I have been involved in the test flying procedures of the Dragoneye and other drones produced by 3D Robotics. Flight Maneuvers have been designed and reviewed.

The second activity consisted of helping Code BL, with guiding possible partners through NASA Ames, introducing them to the most applicable scientists, and accommodating their visits. During those events, possible future collaboration was revised and a follow-up was conducted by the management afterwards.

The third and final main activity consisted of organizing a 5-day business trip for ISU interns and alumni in California, visiting up to 10 different companies.

The other, less significant, activities existed of accommodating visits in the area of NASA Ames for ISU interns and alumni, as well as events involving ISU supporters.

Unfortunately, not all information used during the internship is public information, but this report will give an overview of the internship activities without addressing sensitive details.

1.6 Structure of the report

This report will describe the main activities during the internship in more detail, and will cover the main research with respect to the UTM project. First, the report will describe in short the use of UAS and possible applications. Then the report will cover current activities at NASA Ames with respect to the UAS and loss of signal procedures, before explaining how this will fit in with the overall project and how other companies are involved in the project via the Partnerships office. Finally, the report will describe the other two main activities in more detail, as explained in the internship description. A conclusion will give an overview of the final outcome of the report.

2. Assessing UAS flight testing and its importance for Beyond-Line-Of-Sight (BLOS) UAS control and loss of signal complications

2.1 UAS applications

Besides using UAS as a commercial off the shelf tool for private use and obtaining imagery, this technology will be highly important for other applications. Now, any civilian can buy a small UAS and manually fly it around for pleasure.

Other applications are mostly focused on commercial use. Companies have expressed their interest in a highly intelligent UAS network in order to conduct specific activities. This technology could be used for observation of either agricultural activities, such as forecasting the growth of specific crops, or for observing the reducing area of forest in certain areas.

UAS technologies could furthermore be used for pipeline observations or oil and gas networks. Considering the distance from shore and hard to reach areas, a UAS could be a solution for fulltime monitoring of those platforms.

Observation of environmental changes could be of great interest both for commercial organizations and the government. Monitoring changes due to climate, weather, or people, can be the first step of a Search And Rescue (SAR) mission. Knowing where the problem is and analyzing the right data, could prevent many disasters.

Even though there is a use for UAS in the military and law enforcement, this research is not focused on those areas. The only link between the report and the military is, that the military has built a certain heritage with respect to BLOS operations, which can be used for the UTM project. During the internship period, I had the change to interview a UAS pilot in the navy and ask him basic operational

questions that can publicly be discussed, and will be mentioned in the report section on flight maneuvers.
Below in Figure 3, an overview can be found of possible UAS applications.

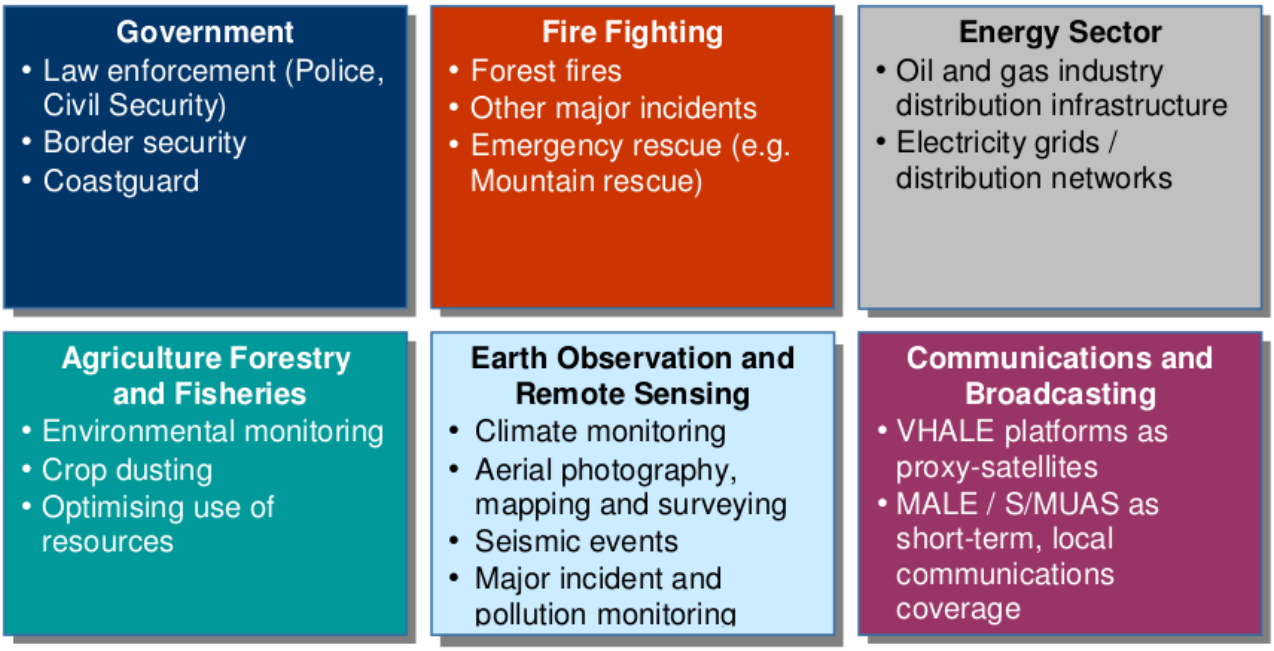


Figure 3: Overview of UAS Applications (Purdue, 2015)

2.2 *The current situation of the UTM project*

As mentioned in the introduction, the UTM project is divided in four different planning stages, called builds:

- Stage one: Establishing the airspace design, taking trajectories into account
- Stage two: Dynamic adjustments and contingency management
- Stage three: Separation and collision management
- Stage four: Manage large-scale contingencies

Currently, the first build is being worked on and I was given the chance during this internship to get involved. The UTM team is divided in the specific software development and the integration of the software, hardware, and payload. During my internship, I have been involved with the last named team.

The basic software that has been developed within the last six months, includes the recognition of mutual UAS activities within the same airspace, and the opportunity to integrate with operational software of other companies, such as Airware. During flight demonstrations, the system prove to be functional with respect to multi UAS operations.

At the moment, flight-testing is conducted of several drones in order to study their flight path and aerodynamic behaviour within rural areas, which will be further described in the next section. The outcome of these tests will affect the calculated flight paths of UAS within the integrated system. In order to allow the second build

of the UTM project to happen, more knowledge is required on the exact dynamics of different kind of vehicles. In order to establish a geo-fencing network, discussions will need to be started on what to do if the UAV cannot establish communication anymore and what could be the solutions.

2.3 Current FAA regulations

The FAA regulations are focused on the air safety in the National Air Space. The question is, what is the NAS and how will this be defined when future operations with UAV's will become normal. Those questions are addressed within the UTM project and cooperation with the FAA is very important. The current rules for small UAV's are as following:

- Fly below 400 feet and remain clear of surrounding obstacles
- Keep the aircraft within visual line of sight at all times
- Remain well clear of and do not interfere with manned aircraft operations
- Don't fly within 5 miles of an airport unless you contact the airport and control tower before flying
- Don't fly near people or stadiums
- Don't fly an aircraft that weighs more than 55 lbs
- Don't be careless or reckless with your unmanned aircraft – you could be fined for endangering people or other aircraft
  (FAA, 2014)

Even though those regulations might sound fair and fitting, they do limit the future operations of UAV's and operations BLOS. In order to change those regulations, safety will need to be proven and an environment will need to be created in which a high number of UAV's can operate together without causing any danger for each other of anybody and anything on the ground. In order to get to this point, flight-testing is a first step.

Certain companies propose to work less with the FAA and instead of focusing on federal government; they would rather focus on local government in order to allow fast and safe operations. An example can be found in the presentation sr. Gur Kimchi gave on behalf of Amazon Prime Air, during the UTM Convention, held at NASA Ames Research Center. Below in Figure 4, there is one of the most significant slides of the presentation. It is clear that Amazon Prime Air would like to enable operations on lower altitudes, allowing less interference with the NAS. No fly zones would be induced, either because of the NAS, certain operations, separation, or high obstacles.

Other suggestions include a 100% secure sense & avoid system, or a mandatory ADS-B receiver on each UAV flying at low altitudes. The last solution was introduced by GoogleX and could be combined with Amazon's way of dividing the low altitude air space. The question will be if the FAA will move fast enough to allow the changes in the UAV environment to happen, or that the changes will happen anyway, less dependent on federal government.

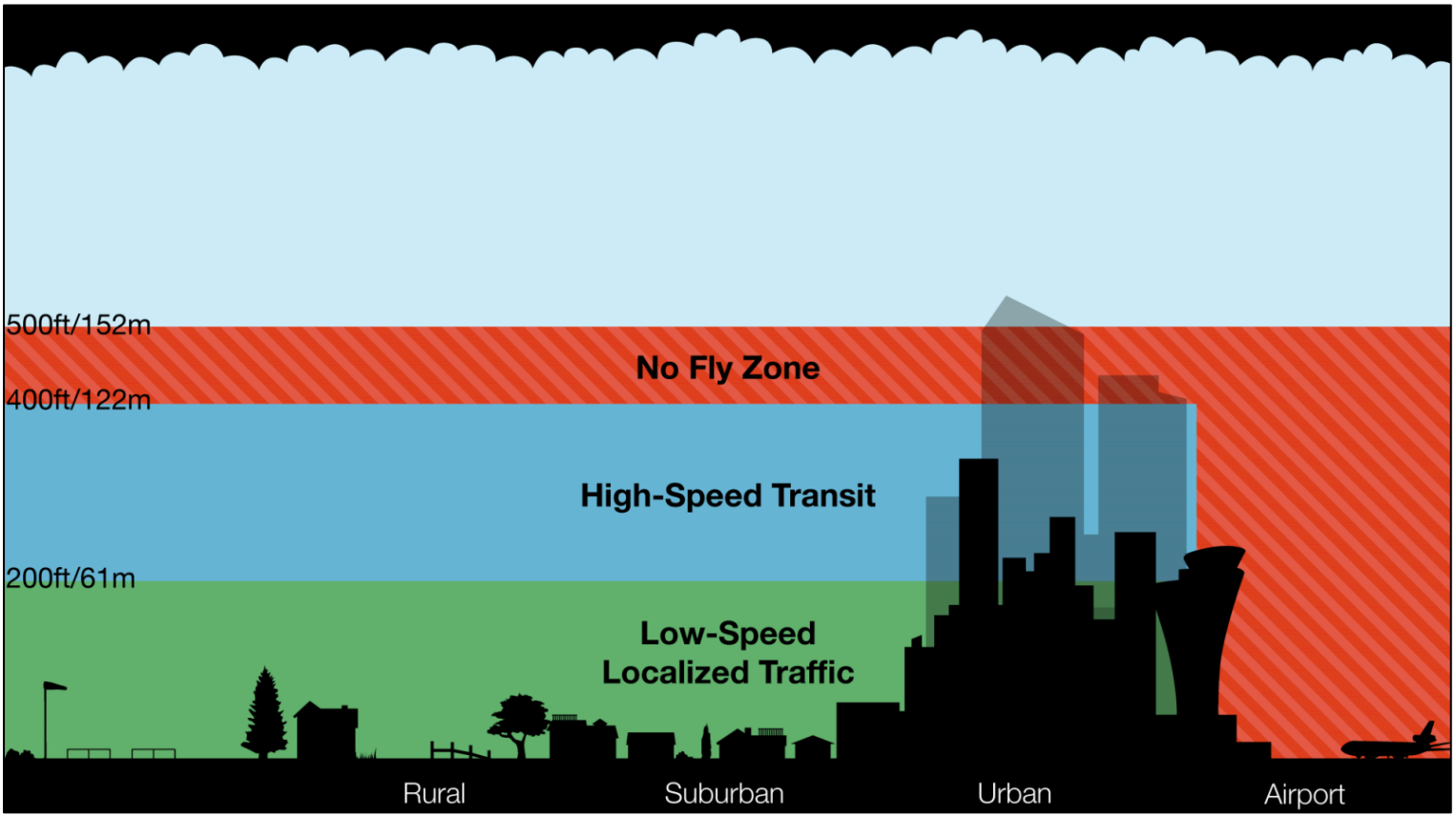


Figure 4: Air Space according to Amazon Prime Air (Amazon, 2015)

2.4 Flight test maneuvers

As mentioned in the section above, flight tests have been conducted with a variety of UAS both in the wind tunnel, as well as using Computational Fluid Dynamics (CFD), and actual UAS flying. During my internship, I have actively been involved with the flight-testing department.

2.4.1 Used UAV's

The UAS used for the UTM project, have been chosen for their variety of dynamics. Both fixed wing vehicles have been used, as well as a tilt rotor or Vertical Take-Off and Landing (VTOL), and rotor UAS with either 3, 4, 6 or 8 rotors. The vehicles could either take off vertically or horizontally, or had to be hand launched. An overview of included UAS and their qualifications can be found below.

Dragoneye

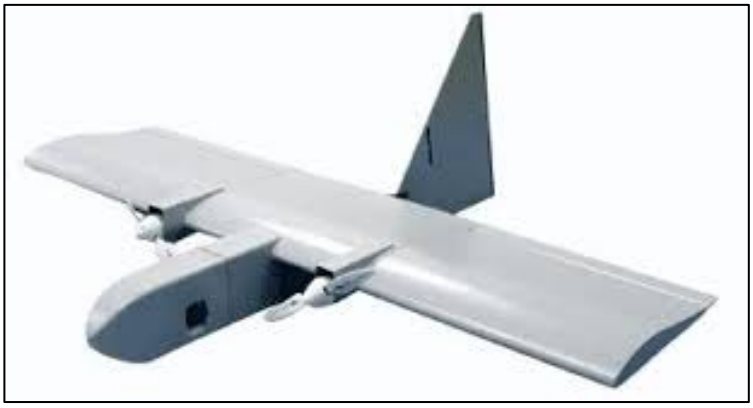


Figure 5: Dragoneye UAV (Designation-systems, 2014)

- Wingspan of 3,75 feet
- Weight of 5,9 pounds
- Line of sight ranges up to 5 kilometers
- Using GPS< possible autonomous operations
- Electric motors
- Semi – military use

IRIS 3-D Robotics:

Figure 6: IRIS 3-D Robotics (engadget, 2014)

- Quadcopter
- Ready to fly
- 16-22 min flight time
- payload capacity 400 g (8lbs)
- Integrated LEDs on all arms for trouble-free directional awareness
- Remote Controller with on-screen telemetry for instant data while flying
- Screw on, self-tightening propellers

X 8 3-D Robotics:

Figure 7: X 8 3-D Robotics (Robotshop, 2015)

- Double quadcopter, 8 rotors
- Ready to fly
- Heavy duty, lifting power extending payload options
- Payload 800 g
- LiveView monitor

Y-6 3-D Robotics:

Figure 8: Y 6 3-D Robotics (3drobotics, 2015)

- 6 Rotors, 3 arms
- ready to fly
- lifting power extending payload options
- payload unknown

Aerovel – flexrotor

Figure 9: Aerovel Flexrotor (Aerovelco, 2015)

- Long range
- Robotic operation
- Vertical Take-off

As demonstrated above, all drones have different capabilities and qualifications. Some are more focused on long-distance and others on critical performance. The challenge here was to combine all different possibilities and create the best flight plan for separate and mutual operations.

2.4.2 Flight Test Theory

During my internship, I got the chance to talk to people at Ames who are involved in the flying of the navy UAV's. One of their main interests is the navigation and flying dynamics at and around an aircraft carrier. Because they already gained experience

from conducting those projects, it only seemed normal to share. General questions have been answered and helped me during further analysis.

The information to collect from the tests, per UAS, included the following factors:

- Body-axis rotational rates (p,q,r)
- Euler angles (φ, θ, ψ)
- Translational accelerations (ax, ay, az)
- GPS position estimates (latitude, longitude, altitude)
- Body-axis velocities (u, v, w)
- Actuator commands
- Rotor RPM (if available)

In order to come up with the correct tests, I have created a presentation for the team and explained the different possibilities to test those factors. In order to do this, an overview has been created of the moments to pay attention to, as can be seen below in Figure 10:

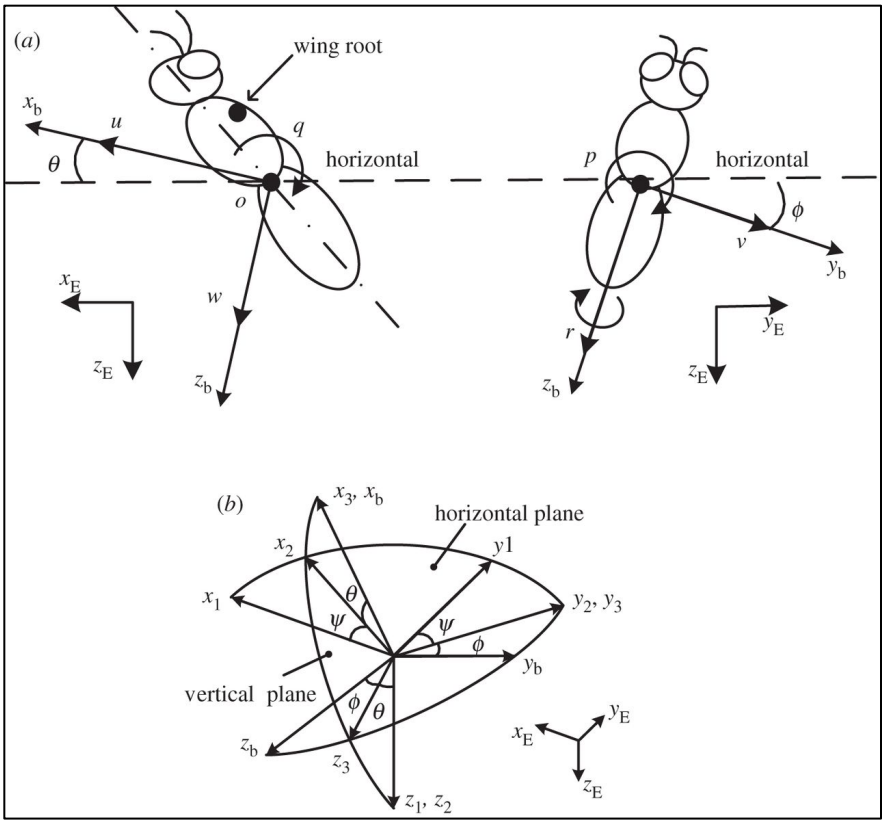


Figure 10: Theory of motion (MIT, 2015)

The system identification methodology is an iterative process and needs a variety of tests before conclusions can be drawn. The methodology is Proportional, Integral, Derivative (PID) based, meaning that all results will be measured with respect to a certain baseline and that this change will say something about the neutral stability. The full model will be validated against the flight data.

During the system identification process, the pilot commands are used to excite the system dynamics in case of operations within Line Of Sight (LOS). From there, aerodynamic and vehicular parameters are identified using either time or frequency based methods. The time and frequency will manually be put in during the first build of the UTM project. The final input is not the pilot command, but the input from the control systems block.

2.4.3 Flight Maneuvers

Several possible flight tests have been identified, an explanation is given below.

Doublet

In order to obtain the dynamic stability parameters, the flight history is needed during this test. Flying doublets is used to obtain the flight history of a key aircraft motion parameter for that specific mode.
A doublet is a cyclic control input that perturbs the UAV on both sides of a trimmed condition, after which a sequence of maneuvers for each control surface (elevator, rudder, aileron) is initiated, without changing the engine power in between. The free response after the doublet is the start of the time history and data will be taken in order to find the neutral stability of the UAV.
Below in Figure 11, a simplified picture of a doublet maneuver can be found. The pilot input is shown in combination with the difference in time.

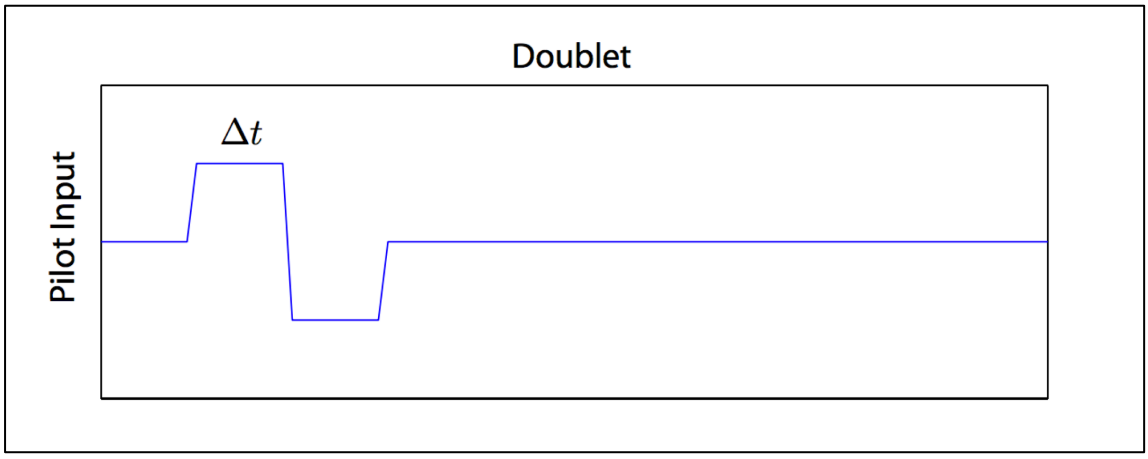


Figure 11: Pilot Input / Time Doublet

The next maneuver that has been researched is the 3211 maneuver.

3211

The 3211 is a combination of doublets. The frequency range is excited by the input and based on a time difference. Full positive amplitude of full negative amplitude is applied to control the surfaces. Depending on which UAV will be used, this maneuver can be applied within LOS. An issue can arise while flying a fixed wing UAV considering the higher speed and low altitude. Three seconds input could deflect the surfaces too much for these conditions.
The input signal consist of full positive/negative for 3 seconds of controls surface deflection, after which full reversal in amplitude takes place for 2 seconds, following by full reversal in amplitude for 1 second, finishing with full reversal amplitude for 1 second. A larger frequency sweep can be reached, using less power than a full doublet.

During the actual flight-testing, a 211 input has been reached with the fixed wing UAV's.

The image below in Figure 12 illustrates the pilot input schematically for a 3211 maneuver.

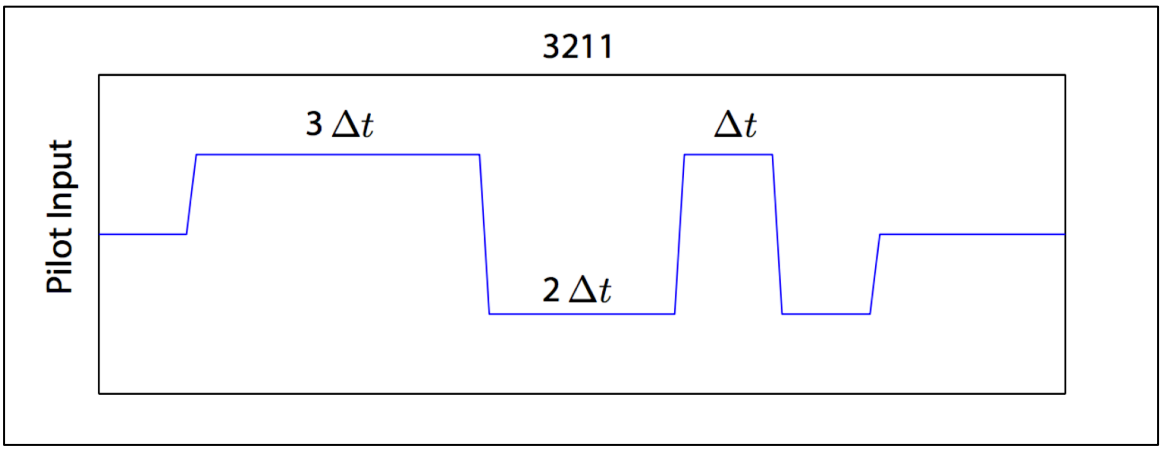


Figure 12: Pilot Input / Time - 3211

The final flight test consisted of a frequency sweep, as explained below.

Frequency Sweep:

The input of a frequency sweep can be generated automatically as part of the control command for a 4-axis control. A good bandwidth coverage and consistency of frequency swept will be necessary and a safety parameter will need to be set in order to reach those requirements. During the flight maneuver, opposite movement of a surface will be conducted with constant deflection, moving faster and faster.

The input frequency is to place the UAV 90 degrees out of phase with the nose on the horizon, but full control movement either positive or negative.
After finding the undamped short period of natural frequency, the controls should be abruptly brought back to neutral, inducing a short period oscillation. The higher the natural frequency, the more response cycles can be reached per unit of time.
In order to produce the right measurements, linear dynamics of the system are used in the form of the Fourier Series.

During my internship, I suggested the UTM project to use the Comprehensive Identification from Frequency Responses (CIFER) software, which was already produced by other NASA centers. The team is considering to request to use this software, which will allow more automated movements and more precise measurements. A Kalman filter will need to be applied with respect to the final results in order to filter out any useless frequencies and signals.

Below in Figure 13, an image can be found which indicates the pilot input as a frequency with respect to the frequency/time graph. Indicated is that the faster the control surface will be moved, the closer the parameters will indicate the natural frequency of the UAV.

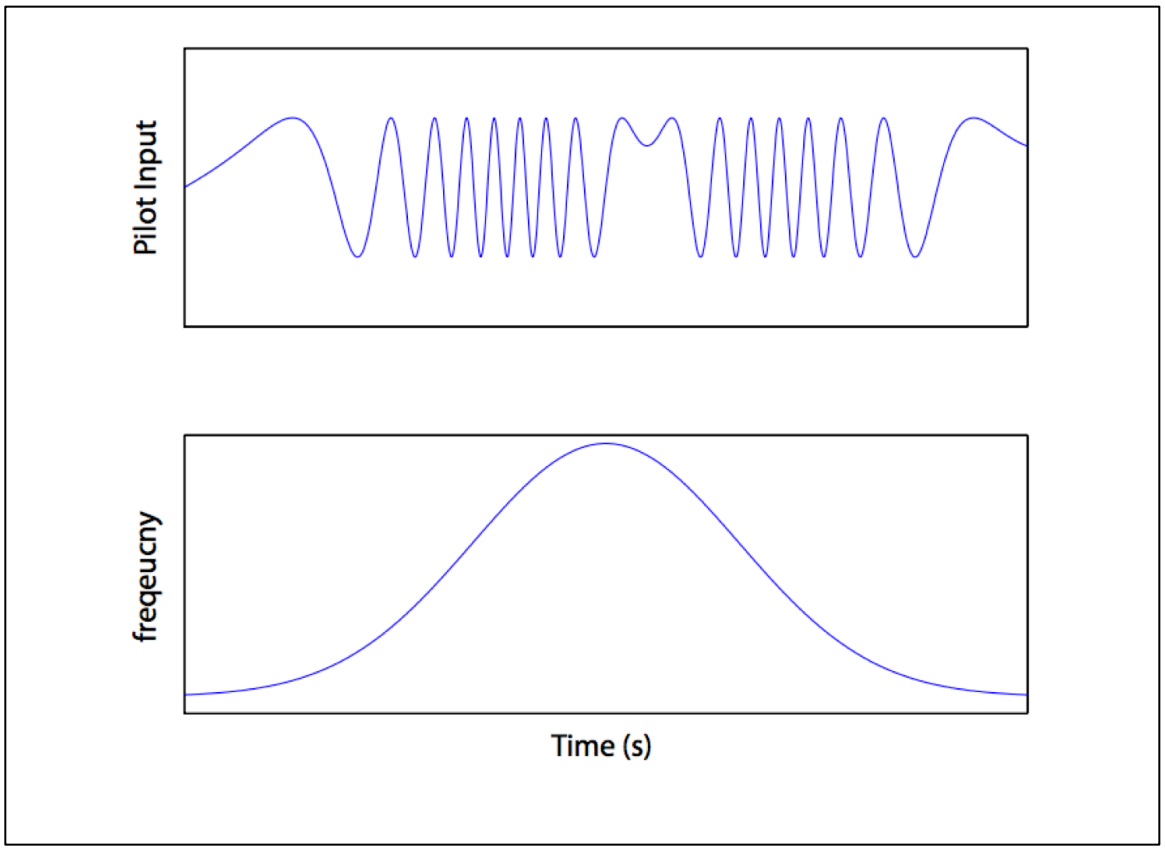


Figure 13: Pilot Input / Time & Frequency - Frequency Sweep

2.5 Loss of signal procedures

Current communication among UAV's and ground stations is mostly based on Ultra High Frequency (UHF) band radio communications and links with Low Earth Orbiting (LEO) satellites. Even though this communication method could allow for long-range communication, there is a low bandwidth of about 50 Kbits/second.
Other communication methods include swarm intelligence and communication between UAV's, using an ADS-B link (space based or not) or Wide Area Augmentation System (WAAS). Considering that redundancy is an important factor during UAV operations and enabling the FAA to adapt the regulations to move forward to BLOS operations, a stable communication link is an important requirement.

Current communication links can be limited by weather for example. Operations BLOS cannot allow a loss of communications, especially not in civilized areas.

Even if sense & avoid technologies will be fully developed for the appropriate operations, it would still be wise to allow a maximum of UAV's in the same area for separation purposes. And even then, if companies lean towards an open source platform, it will be important to guard cyber security and control the overall operations.

Using a low-cost ADS-B receiver in combination with a thorough sense & avoid system, could lead to a fully controlled UAV airspace. The first build of the UTM project does not include prioritizing capabilities, but it will be crucial for the next build to be able to prioritize certain operations such as SAR above recreational UAV's operating in the same area.

One of the methods I have considered during my internship is computer vision and on-board cameras, used as either a primary or redundancy system. This system could allow an independent navigation method in case the signal is lost with the GPS system or the distant controller. Certain operations will require an independent system, either in low coverage areas or bad weather conditions.

Another issue that needs to be taken into account is the case of a non-cooperative UAS. This issue will be of interest during flight-testing and either the UAS environment will need to be able to avoid those non-cooperative vehicles, or there should be a method to cancel out the operations of the drone.

The last option could be of interest, considering that it can be relatively easy to build in a mechanism to cancel out the operation of the UAV after a loss of link. The issue that can be identified, is the location of the UAV at the moment it will be brought down. If the coordinates of the last location can be saved on-board, it can autonomously fly back to this location before coming down.

Another solution is a complete return of the UAV to the take-off location. This option will be less interesting if the UAV is further away from the starting position, especially in hostile areas or sensitive information.

As long as the UAV can be identified from a distance, as well as its operator, and it is checked in into a bigger network of operators, other UAV's will be able to know about its position and avoid the non-cooperative vehicle. A combination of full independent redundancy and independent awareness of the location will be a good combination for a safer UAV environment. If those two requirements are met, return to base will be less tricky. On the image below in **Error! Reference source not found.**, a network can be seen with redundancy via both a BLOS link and a LOS link.

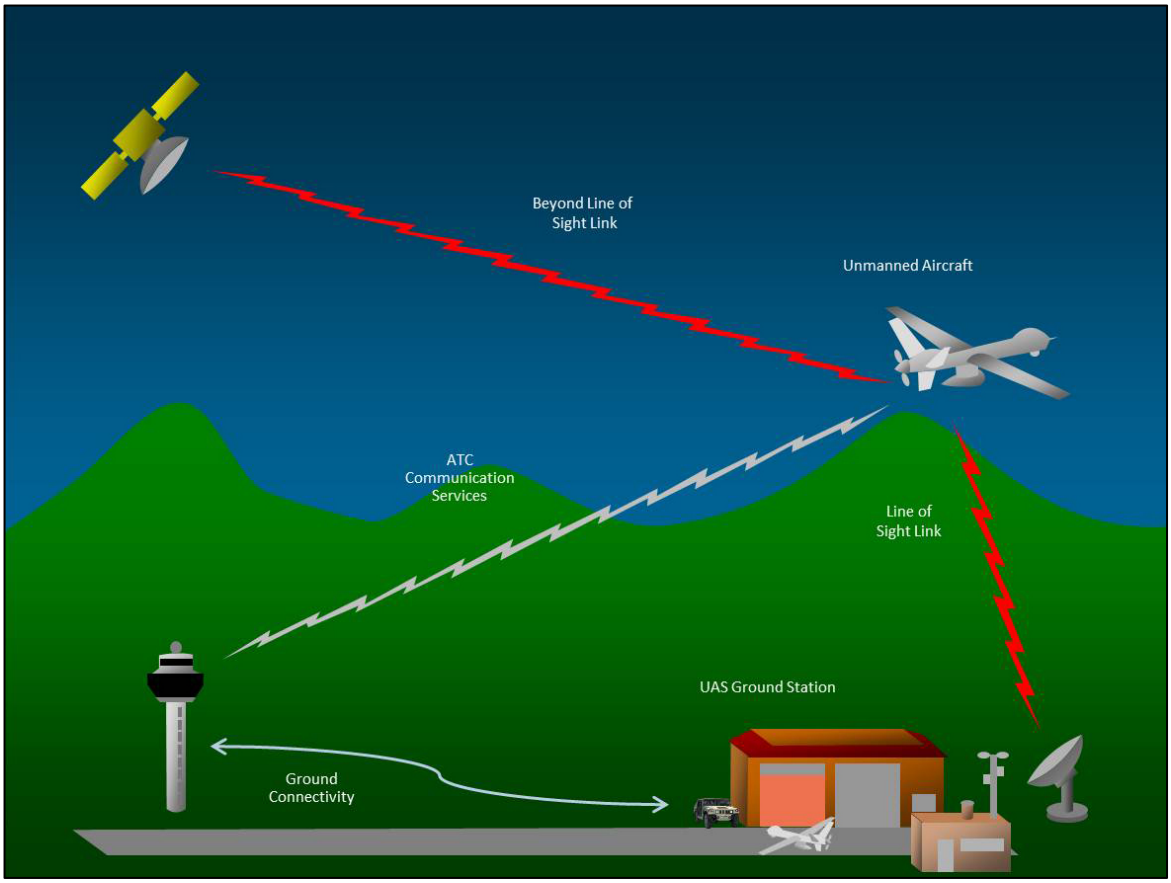


Figure 14: UAV communication network (NASA, 2015)

Partnerships

In order to make the UTM Project a success, great importance can be found in the collaboration with big organizations such as the FAA, as well as with private industry. At the moment, there are active agreements with companies such as 3-D robotics for the use of their UAV's, but partnering with companies such as Amazon and Google will make a big difference in the progress of the project.

While the FAA is aiming for an airspace that is as safe as possible and will not harm anybody either in the air or on the ground, companies such as Amazon and Google wish to push forward and start operating BLOS. Depending on how the data will be retrieved for the UTM project and on the speed the FAA will adapt current regulations; BLOS operations will be conducted in the near future.

One of the main concerns of current UAV companies is the relatively slow paste the FAA is working in. Much competition is coming from countries such as China, where regulatory organs have already allowed UAV operations BLOS for specific purposes. The technology exists, but the aim is to move forward as fast and safe as possible.

During my internship I got the opportunity to talk to several companies involved with the UTM Project, including Airware, Airmap, Amazon and Google. Even though there are active agreements, my suggestion is to work closer with local government worldwide in order to identify common interest and possible UAV usage for local organizations. Most companies and institutions that are momentarily partnering with NASA Ames are of significant size and might not be able to be as dynamic as local institutions. Even though the UTM Project works closely with the FAA, it might be worth considering more locally operations and possibilities.

3. Further Internship Activities at International Partnerships

The guidance of different possible partners through NASA Ames Research Center, was a significant part of the internship. This included not only helping accommodating the visits, but also the scheduling and ensuring of the follow up of the schedule during the day itself. These activities involved great professionalism and diplomatic knowledge, considering that most incoming visitors were international and of a high diplomatic level.
Before each visit, it was important to go over the schedule, know where to go and know about the different departments at NASA Ames. During these activities, I got the chance to not only talk about NASA Ames as a center and identify possible future collaboration, but also to see the center in detail and visit departments that are not open to general public.

3.1 Visits at NASA Ames

Below you find a list of visitors, including existing partners and possible future partners, and an explanation of the connection with NASA Ames and possible outcomes:

Korea Evaluation Institute of Industrial Technology (KEIT) – June 3
Before the visit, there were already active agreements between KEIT and Ames. During the visit, it was confirmed that the cooperation will possibly increase in future and both parties could collaborate on different fields, but specifically on autonomous systems and driverless cars.

Chief Defense Scientist, Singapore Ministry of Defense – June 4
Because of the change of the management at NASA Ames, several countries visited the center over the summer with the purpose to confirm existing and future collaboration, which is what the Chief Defense Scientist of Singapore has done.

Industrial Technology Research Institute – June 17
Current active agreements exist between several companies and institutions with NASA Ames and during this visit, a confirmation was given for further future collaboration.

His Excellency Evaldas Gustas – June 18
His Excellency Evaldas Gustas of Lithuania has been involved in projects with Lithuanian inters at NASA Ames and follow up projects via the former management of NASA Ames. During this visit, confirmation was given that Lithuania can keep sending students to Ames and will cooperate with future projects.

World Bank Disaster Risk Management Team – June 30
The World Bank sent the Disaster Risk Management Team for the North Africa and Middle East region. There was great interest in Earth observation data from NASA Ames and a follow up will include identifying interesting technologies that will benefit the region.

Mr. Andy Weir – June 30
As the author of 'The Martian', Andy Weir has cooperated with NASA intensely. Scientist Jim Green has been the scientific advisor for both the book and the movie. Andy Weir gave a colloquium to the Ames interns, after which he went for a tour on the terrain.

Her Excellency Dilma Rousseff – July 1
As the Brazilian president, Her Excellency Dilma Rousseff requested a meeting with both delegates of the Brazilian government and aerospace executives. Future collaboration has been discussed.

Mexican talented students tour – July 15
A group of 30 students has been selected to spend two weeks in Silicon Valley in order to visit companies of interest. NASA Ames has been on their list for several

years now and students go the chance to ask questions and pay a visit to the Ames facilities.

Dava Newman visit – July 16
During one of the colloquiums, Dava Newman paid a visit to NASA Ames. She got the chance to talk to students and spent time with them. She paid a visit to the Ames facilities as the new NASA deputy director.

Temple Grandin Visit – July 21
During one of the colloquiums, Temple Grandin talked about her experience with autism and her ideas on the current education system. She requested NASA to get more involved with inspiring young people all over the country, not just in California. Many people were willing to help out with small projects.

Dartmouth Alumni Tour – July 24
A group of 20 Ivy League alumni paid a visit to NASA Ames, where they were taken to a big variety of facilities and got to meet Ivy League alumni working at NASA Ames.

Trepcamp Students – August 3
A group of 30 talented school children and students visited NASA Ames as part of a summer camp. The program was part of STEM education and I got the chance to talk about personal experience and answer questions.

All activities both gave me the opportunity to talk to the visiting parties and get to know NASA Ames as a center. Considering how much Ames specifically collaborates with international partners, it gave me a good idea on what it involves to build a relationship and work on future opportunities. It was clear that most technical projects seem to go on by themselves, but this internship gave me the opportunity to see what is going on behind the doors and how much in involves to create sustainable relationships with partners.

The period of my internship was particularly interesting because the management of NASA Ames just changed and many partners wanted to discuss the consequences for existing agreements or future possibilities. In order to create the relationship, in involved initial contact via a visit or other meetings, after which mutual interest is established in a certain topic. Most collaboration is for educational purpose, especially with countries that normally do not interact with the United States government. From there, other collaboration can be possible, but this was outside the scope of the internship.

After each visit, a report has been written in order to inform the management and NASA Headquarters on what the expected follow up steps are. My task was to write those reports and looking for possible mutual interest, based on the information retrieved during those visits.

During the many activities that were conducted during the internship period, I have been involved in organizing and accommodating them.

3.2 The ISU Space Coast Trip

During my internship, I have planned, organized and managed the so-called ISU Space Coast tour. Every year, the group of ISU interns will, together with ISU alumni and other interested NASA Ames interns, visit aerospace companies along the west coast of the United States. This year, I have been in charge of this weeklong event and below I will describe how those activities have been conducted.

In order to plan such an event, a clear schedule was needed. Working directly with people and being dependent on other people, turned out to be a challenge and could either speed things up or slow things down.

The ISU Space Coast Trip was an event that required the proper people for the right tasks, which is why the planning started with the choice for the right Points of Contact (POC's) in order for them to fulfil the right tasks.

Since this was not the first time this event took place, much was learned from previous experiences. With supportive supervision, it was not difficult to find the right Points of Contact. Being the POC for current ISU students myself, another POC was chosen for ISU alumni in the area of Silicon Valley, one POC was chosen for ISU alumni in the rest of California, and one POC was chosen for other international students at NASA Ames Research Center.

The tasks of the POC's was to collect the data from people who wanted to join the trip, and reaching out for further information. In the meanwhile, my task consisted of creating relationships within the companies of interest by contacting them and explaining the situation. The companies were chosen from a list I created in the first week of the internship, with names of all companies of interest in California.

After shortlisting about 15 companies from the list, based on location, transport capabilities, general interest, and available alumni working in the respective companies, contact has been initiated. The ISU network within California proves to be significant, considering the quick responses and help that was received after reaching out.

A tentative schedule has been produced, based on feedback from the companies and the locations with respect to transport capabilities. After gaining feedback from all the companies, it was clear that 10 could offer the group the opportunity to be shown around in the facilities. A challenge was to line up all the visits so as many companies could be visited as possible, without having to move continuously.

An overview of the visited companies can be seen below in Table 1, together with the final schedule in Table 2. At the time of the production of the schedule, Boeing had not yet confirmed the specific time of the visit, since this will be confirmed later during the week.

Table 1: Visited Space Companies

Space Systems Loral
Lockheed Martin
Spire Satellites
Planet Labs
Millennium Space Systems
Boeing
SpaceX
Virgin Galactic
The Spaceship company
Masten Space Systems

Table 2: Schedule ISU Space Coast Trip

VISIT AGENDA	**Monday August 17**

Dress code: Business attire

Time	*Agenda*	*Location*	*Speaker/POC*
08:30 AM – 09:15 AM	Drive from NASA Ames to SSL	SSL 3825 Fabian Way Palo Alto, CA 94303	Ms. Daphne de Jong *NASA Ames / ISU*
09:30 AM – 11:30 AM	Touring the SSL facilities	SSL 3825 Fabian Way Palo Alto, CA 94303	Ms. Daphne de Jong *NASA Ames / ISU*
11:30 AM - Afternoon	Either spending time in SF or driving back to NASA Ames	San Francisco	Ms. Daphne de Jong *NASA Ames / ISU*

VISIT AGENDA	**Tuesday August 18**

Dress code: Business attire

Time	*Agenda*	*Location*	*Speaker/POC*
8:30 AM	Meet in front of the NASA Ames main gate	NASA Ames Research Center, Moffett Field, 94035	Ms. Daphne de Jong *NASA Ames / ISU*
8:30 AM - 10:00 AM	Driving to Spire Satellites	Spire 33 Norfolk St San Francisco CA 94103	Ms. Daphne de Jong *NASA Ames / ISU*
10:15 AM – 10:30 AM	Meeting in the Spire Lobby	Spire 33 Norfolk St San Francisco CA 94103	Ms. Daphne de Jong *NASA Ames / ISU*
10:30 AM – 11:00 AM	Morning snacks and coffee	Spire 33 Norfolk St San Francisco CA 94103	Ms. Daphne de Jong *NASA Ames / ISU*
11:00 AM – 11:30 AM	Tour and presentations	Spire 33 Norfolk St San Francisco CA 94103	Ms. Daphne de Jong *NASA Ames / ISU*
11:30 AM – 13:30 PM	Lunch & free time	San Francisco	Ms. Daphne de Jong *NASA Ames / ISU*

13:45 PM	Meet in the lobby at Planet Labs	Planet Labs 346 9th Street San Francisco 94103	Ms. Daphne de Jong *NASA Ames / ISU*
14:00 PM – 16:30 PM	Tour at Planet Labs, including presentations	Spire 33 Norfolk St San Francisco CA 94103	Ms. Daphne de Jong *NASA Ames / ISU*
16:30 PM	Travel back to SF / Ames	SF / Ames	Ms. Daphne de Jong *NASA Ames / ISU*

WEDNESDAY: TRAVEL TO LA

We meet at NASA Ames at 07:30 in order to start driving.

VISIT AGENDA	**Thursday August 20**

Dress code: Business attire

Time	*Agenda*	*Location*	*Speaker/POC*
08:45 AM	Meet the group at Millennium Space Systems	Millennium Space Systems 2265 E El Segundo Blvd El Segundo CA 90245	Ms. Daphne de Jong *NASA Ames / ISU*
09:00 AM – 09:20 AM	Breakfast & Coffee	Millennium Space Systems 2265 E El Segundo Blvd El Segundo CA 90245	Ms. Daphne de Jong *NASA Ames / ISU*
09:20 AM – 10:15 AM	Touring the Millennium Space Systems facilities	Millennium Space Systems 2265 E El Segundo Blvd El Segundo CA 90245	Ms. Daphne de Jong *NASA Ames / ISU*
10:15 AM – 13:00 PM	Free time	Los Angeles	Ms. Daphne de Jong *NASA Ames / ISU*
13:00 PM – 13:45 PM	Driving to SpaceX	SpaceX 1 Rocket Road 90250 Hawthorne, CA	Ms. Daphne de Jong *NASA Ames / ISU*
14:00 PM – 15:30	Touring SpaceX	SpaceX 1 Rocket Road 90250 Hawthorne, CA	Ms. Daphne de Jong *NASA Ames / ISU*

Waiting for further details on the visit to the Boeing facilities

VISIT AGENDA	**Friday August 21**

Dress code: Business attire

Time	*Agenda*	*Location*	*Speaker/POC*
10:45 AM	Meet at the Virgin Galactic facilities	Virgin Galactic 3872, 4004 East Conant Street Long Beach, CA 90806	Ms. Daphne de Jong *NASA Ames / ISU*
11:00 AM – 12:00 PM	Tour the Virgin Galactic & The Spaceship Company facilities	Virgin Galactic 3872, 4004 East Conant Street Long Beach, CA 90806	Ms. Daphne de Jong *NASA Ames / ISU*
12:00 AM – 14:30 PM	Free time	Mojave Spaceport	Ms. Daphne de Jong *NASA Ames / ISU*
14:45 PM	Meet at the Masten Space Systems facilities	Masten Space Systems 1570 Sabovich St Mojave, CA 93501	Ms. Daphne de Jong *NASA Ames / ISU*
15:00 PM – 16:00	Tour Masten Space Systems facilities	Masten Space Systems 1570 Sabovich St Mojave, CA 93501	Ms. Daphne de Jong *NASA Ames / ISU*
16:00 AM – LATER	Meet ISU alumni in LA	LA	Ms. Daphne de Jong *NASA Ames / ISU*

SATURDAY: FREE TIME

SUNDAY: TRAVEL BACK TO BAY AREA

3.2.1 Further factors – ISU Space Coast Trip

Besides producing a schedule, information on the specific companies has been found and I tried to arrange appointments with the Human Resources (HR) department within the respective companies in order to give the visiting students the opportunity to talk about job opportunities.

The trip gives a significant inside perspective within the space industry, considering that the companies talked about the current activities, future plans, and how this fits in with other space related organizations, including NASA Ames.

Planning and managing this event gave me the opportunity to experience activities behind the screens and talk to people with great knowledge with respect to the aerospace industry. Besides planning the company visits, it required cooperation with people continuously, which turned out to be a challenge. Many late responses were given by email and it was sometimes complicated to schedule all activities according to everyone's preference.

Planning included the accommodation and transportation as well. Being responsible for a professional group and the reputation of ISU, required thorough organization. Accommodation was found in Hollywood in the L.A. area for the entire group and transportation was arranged by rental cars. This gave the group the right liability in case something would go wrong, which should be prevented at all times during a professional event. To give an impression of the covered area and planning complexity, please see the simplified transportation plan below in Figure 15.

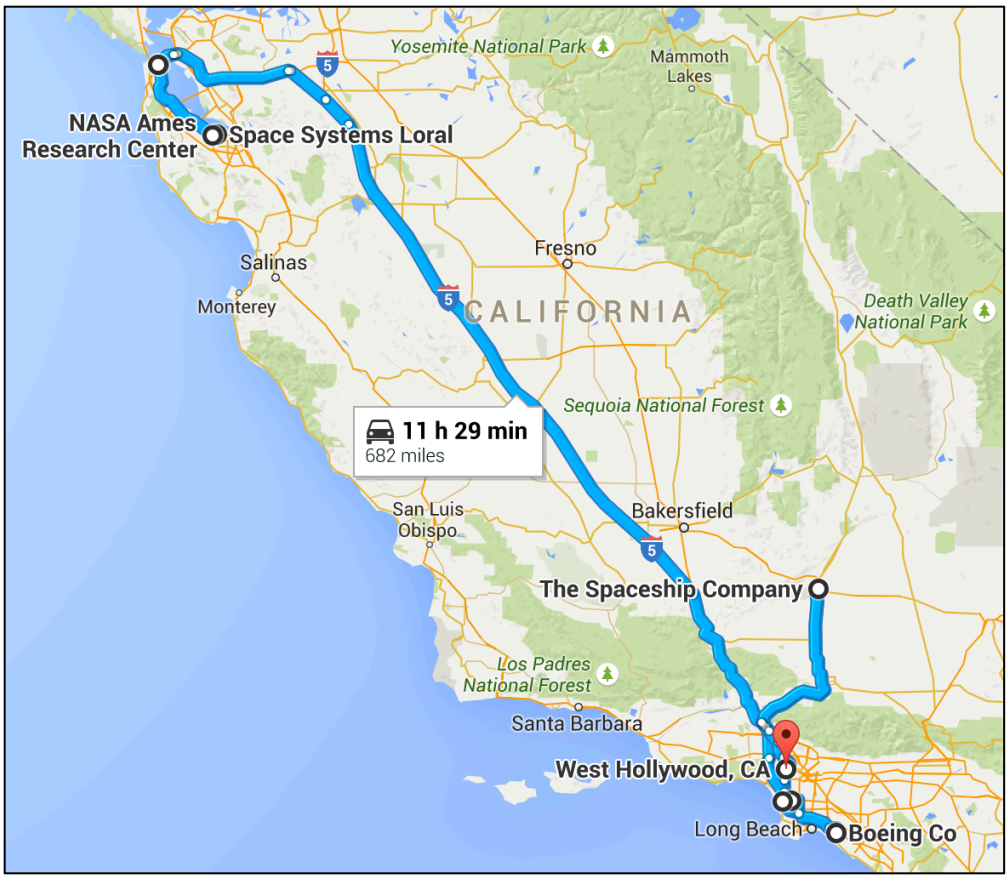


Figure 15: Transportation Plan

At the time this report was produced, the ISU Space Coast Trip has not taken place yet, but the scheduling and management has been working out so far. Currently it looks as if the event will be successful. Any questions about the trip can be addressed afterwards and will be discussed during the Internship presentation. Overall, the trip will be a valuable asset to the internships and professional experience of the participants. Despite the low attendance of current ISU interns for financial reasons, other ISU alumni participated.

4. Remaining internship activities

The remaining internship activities consisted of organizing and accommodating events to reunite the ISU community in Silicon Valley. Besides organizing dinners with mr. Gary Martin and dr. Pete Worden and ISU culture night, I have organized an ISU alumni reunion in Palo Alto and have initiated other events.

The internship started with organizing and accommodating a resume workshop for all ISU interns with the head of students programs at NASA Ames, giving an inside perspective on the expectations for an American resume as a preparation for the professional visits.

4.1 DFJ Visit

Besides organizing those events, I have been in charge of organizing professional visits to companies in the area of NASA Ames. Draper Fisher Jurvetson (DFJ) was the first professional stop, where a group of ISU interns and alumni got the opportunity to talk to partners working in the Venture Capitalist area and ask about on-going space related projects.

Steve Jurvetson, one of the partners of DFJ, is in the board of directors of SpaceX and Made In Space, as well as other space focused companies. Hearing about current project was an inspiration for the group.

As a space fanatic, Steve Jurvetson has collected a big variety of space artefacts, including a MIR cockpit and Apollo mission's related objects. The office was turned into a museum, giving the group the chance to learn about the connections between DFJ and space focused projects.

Another visit will be conduced to the headquarters of Tesla in the week after finishing the internship, but this activity has been planned during the internship period.

4.2 Activities at NASA Ames Research Center

NASA Ames Research Center is used to having about one thousand interns over in the summer periods, which makes it a very international and open center. Because of this heritage, specific events have been organized for NASA interns and I have actively participated in them. Separate colloquiums have been organized almost twice a week, given by significant scientists or figures within the space industry, offering a big variety of space related education. An overview of given colloquiums can be found below.

Besides the informative and educational colloquiums, NASA Ames gave interns the opportunity to use the so-called Spaceshop on-site, where many facilities were available for hardware production. Included in the available equipment was a laser cutter, vinyl printer, 3-D printers, and many more. Because of the long opening hours and availability of the employees in the Spaceshop, I had the opportunity to follow courses in specific fields in order to improve my hands-on skills. In specific, I have been focussing on the 3-D scanner and 3-D printer, assuming that those skills will be most helpful developing future ideas.

NASA Ames Research Center also offered the opportunity for interns to develop themselves in a professional matter, introducing them to poster presentations and a professional environment. Because of the nature of my research, it was not possible to attend the poster sessions myself, but I have been watching the presentations and posters, giving me a better idea on the activities at NASA Ames.

4.3 Conferences

Finally, I had the opportunity to attend conferences at NASA Ames Research Center and the area. During the internship period, I have attended the New Space Conference, the Solar Systems Exploration Research Virtual Institute (SERVI) Conference, and the UAS Traffic Management (UTM) Convention.

4.3.1 The New Space Conference

The New Space Conference took place in San Jose, where I have been attending presentations and meetings with respect to current development in the new space industry. I had the chance to talk about projects at companies such as SpaceVR and Planet Labs.

4.3.2 The SERVI Conference

During the SERVI Conference, I got the chance to meet significant scientists from all over the world and space leaders within their own field. The conference was focused on the science behind Lunar exploration and the future perspective of companies involved.

Organizations such as Lunar Mission One (LMO) have participated, who I wrote my Individual Research Project (IRP) with. This is where I got the chance to talk to the LMO management and participated in the launch event of the discussions for the next steps to take within the company.

4.3.3 The UTM Convention

Furthermore, I have been participating in the UTM Convention that was being held at NASA Ames. The team that has worked with my research, has organized this convention, which is why participating was a big priority. World leaders have made their announcements of how they would like to change the skies and fill them with UAS.

The general issues with respect to UAS traffic management were addressed and commercial companies from all over the world got the chance to talk about their ambitions and where they fit within the overall developments. The main issues were focused on safety of the National Air Space (NAS), as well as the competition between companies and how possible cooperation could work.

Industry leaders such as NASA Ames Research Center, Amazon Prime Air, and Google X, had the chance to speak about specific challenges with respect to the management of the airspace and the overall sound was that companies do not want to depend on the developments of new regulations of the Federal Aviation Administration (FAA) for controlling the NAS. Alternatives were described and

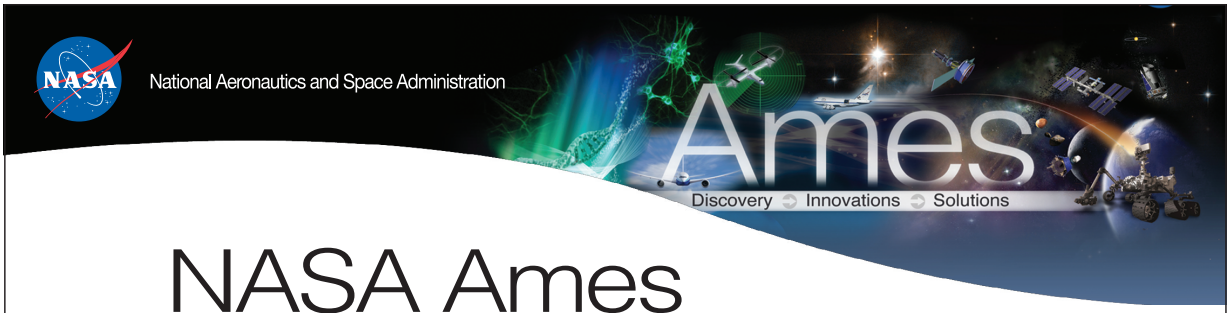
included the organization and management on a lower altitude, not necessarily conflicting with the NAS. Local government could be an alternative focus, since the discussion started where the NAS starts exactly and if flying at low altitudes is the responsibility of the FAA or not.

Local companies communicated with established organizations so the heritage could be passed on. It was obvious that most organizations preferred an open source based network in order to establish the UAS sector worldwide.

Lots of experience can be taken away from the UTM convention and the event gave an overall overview of the current developments in the UAS sector.

4.4 CSA – Small satellite missions

Finally, I got the chance to attend an 8-hour teleconference with the Canadian Space Agency (CSA) with respect to small satellite missions, after which I got to do research on this specific topic. The purpose of the meeting was to exchange information on low cost space exploration, the emerging genre of mission and launch opportunity, Nano satellites and piggyback payloads between CSA and NASA Ames Research Center. Besides writing the NASA internal report, I have been involved with the discussions during the day.



NASA Ames
2015 Summer Series

Seminars are from 11:00 a.m. to 12:00 p.m. *Except for July 16, which will be at 1:00 p.m.

june	Tuesday, **June 9**	**Lee Stone**	*Brain Function through the Eyes of the Beholder*	Building 3: Ballroom
	Thursday, **June 11**	**Christina Ngo**	*It's a Fluid World*	
	Tuesday, **June 16**	**Ruth Globus**	*Flying through the Ages: Rodent Research for Human Health*	
	Tuesday, **June 23**	**José Funes**	*A Cosmic End: from the Earth to the Universe*	
	Thursday, **June 25**	**Jeremy Vander Kam**	*Burn to Shine: Experiences and Lessons from the Orion Heat Shield*	
	Tuesday, **June 30**	**Andy Weir**	*The Martian: How Science Drove the Plot*	
july	Thursday, **July 2**	**Kevin Reynolds**	*Affordable Airplanes: Modular Design and Additive Manufacturing*	N201: Auditorium
	Tuesday, **July 7**	**Chuck Duff**	*Taking the Rearview Mirror Test and Passing with Flying Colors!*	
	Thursday, **July 9**	**NACA Panel**	*The NACA: A Hundred Year Legacy*	
	Tuesday, **July 14**	**Jason Crusan**	*Pioneering Space: Not Your Great-Great-Grandparent's Manifest Destiny*	
	Thursday, **July 16***	**Charles Bolden & Dava Newman**	*Town Hall Meeting with the NASA Administrator and Deputy Administrator*	
	Tuesday, **July 21**	**Temple Grandin**	*Helping Different Kinds of Minds Solve Problems*	
	Thursday, **July 23**	**Robert Swan**	*Leadership on the Edge*	
aug.	Tuesday, **August 4**	**Rhea Seddon**	*Rats, Folks, and Jellyfish: Studying Life in Space*	N201: Auditorium
	Thursday, **August 6**	**Eugene Tu & Tom Edwards**	*NASA Ames' Role in the Future of Exploration, Science, and Aeronautics*	
	Tuesday, **August 11**	**Justin Kasper**	*Sending a Probe into the Atmosphere of Our Sun*	
	Thursday, **August 13**	**William Colburn**	*Destroy Saturn V! and other Apollo Topics*	
	Tuesday, **August 18**	**Patricia Parsons-Wingerter**	*Fractal-Based Mapping of Vascular Patterning For Human Space Exploration*	

All seminars last 60 minutes including questions. Reception to follow.

Figure 16: Colloquium Schedule (NASA, 2015)

5. Benefits of the internship

Conducting my internship at NASA Ames has given me the opportunity to learn more about NASA as an organization. Before coming here, I though I knew NASA well enough to talk about and know about their operations. It turns out that I was not aware of how NASA really works.

During this internship and the nature of the non-technical / technical combination, I got the chance to see almost the entire Center and meet most of its significant people.

Just the fact that my person thoughts were that NASA was one organization, divided into different areas, seems iconic after the internship. Theoretically this is the case and all centers are operating under the same conditions. But in practice dealing with different centers feels like dealing with different companies. All cultures are different. During the many events held at NASA Ames and in the area, I got to meet people working at NASA Ames, NASA Goddard, NASA JSC, NASA HQ, and NASA KSC. It almost felt like traveling between countries and speaking another language. Having this experience truly opened my mind with respect to NASA.

During the internship, I feel like I truly got to know NASA Ames Research Center. Not only did I get the chance to work for people such as mr. Terry Pagaduan or mr. Gary Martin, but I also got to meet the center director dr. Eugene Tu several times and even the president of Brazil.

Here, I learned not to only think from a technical perspective, but to put all the puzzle pieces together and really try to find the reasoning behind certain decisions. What can look like just a visit form a Consul General for one person can mean so much more to me now. This internship gave me the inside perspective on the reasoning behind reaching out to other countries, including countries such as China. The space industry needs these international bridges and Ames seems the right center to comply to this.

It was interesting for me to experience the change of the management within the center and how employees and contracting organizations reacted on this. Many countries and companies wanted to re-establish their relationships with Ames and were interested in further future cooperation. This is a sign of good past experience and mutual interest.

During this internship it felt like I accomplished something, got something from the ground. I got to work closely with people in a nice way and in a no-so-nice way. Even though I got to know people with great expertise, sometimes working close to people and depending on their work can be tiring and can seem less efficient. But I learned to deal with this and to work my way around problems and road blocks.

Code BL truly helped me to develop both my management skills and human skills. I got to deal with people from all corners from society and got inspired by all the

expertise. Being invited for meetings of such high importance was a true honor and gave me a great inside perspective.

Code A gave me the opportunity to work on my other passion for UAV's. Meeting people with such clear ideas on how the future of unmanned systems should look like, was very inspiring. I truly believe I grew because of them and the high expectations. It was challenging to be part of a project of such magnitude and still get the chance to present for them and talk to them like an equal, considering their high positions. I learned a lot about the possible future for UAV's and how all the companies fit in.

Comparing the UAS industry with the start of the aircraft industry, we are just at the beginning of an era. Where the aviation industry started with many competitors, the UAV industry is finding it's main leaders who are most likely to succeed and stay until the end. Even though there are hundreds of involved organizations, there might be a future of 3 or 4 main industry leaders and a merging process of other smaller companies during the increasing industry developments.

Personally I feel that I am very grateful to have ended up in such an inspiring organization at such a great location. Ames gave me a warm welcome and the center fits so well in Silicon Valley. Emerging technologies seem normal here and the word disruptive seems redundant. Everyday, Google cars drove over the campus in order to test their new technological developments. I got the chance to talk to inspiring scientists such as dr. Terry Fong about intelligent robotics and to dr. Parimal Koperdekar about how he thinks UAV's will change daily life. Such people are a great inspiration and I wish everyone would have the chance to talk to them.

Even more inspiration could be gained from meeting high school students as part of a STEM education plan at NASA Ames and getting the chance to talk with them about jets and control systems and how we can produce drinking water from human waste. It has been a real pleasure working with people from all countries and societies.

Most grateful I am for my mentors and supervisor. Mr. Terry Pagaduan is a great inspiration and really knows everything about partnerships. It was an honor to work for his department.

Mr. Scott Yim was a great mentor and coach. He really helped me to meet the right people and conduct the research I wanted to focus on. He gave me the inside perspective on the operational side of NASA Ames, clear and honest.

6. Recommendations to future ISU students at NASA Ames

Future ISU students that are considering an internship at NASA Ames, I would like to tell to go for it. This has definitely been a very inspiring time, giving me the opportunity not only to get to know the center very well, but also companies in the area that I have heard of before, but never actually knew much about. Those

companies that change the technology sector worldwide and pus forward the limits for education. This is the place you want to be.
NASA Ames is a very open and varied center with research in many different fields. If you are a biologist, go to NASA Ames. If you are an Artificial Intelligence specialist, go to NASA Ames. And if there is a field of research you would like to work in, but is not currently worked on, definitely go to NASA Ames.

This center knows very well how to deal with interns and the key is to be open for new things and take initiative. The internship can be as good as you want it to be, by guiding it yourself. Most departments are open for new research and new ideas. The placement can be as good as you want it to be.

My main recommendation is to go outside and do things besides the daily working routine. Every time foot is set outside the gates of Ames, there are other interesting people and organizations with their own unlikely view on reality. Many people in the area are highly educated, knowledgeable, young and motivated. There are many organizations that are open for questions and comments.

Many events are organized in the area during the summer. Those are definitely worth checking out. Many technology conferences are organized, but also festivals.

Furthermore, it is recommended to stay at the NASA Exchange Lodge during the stay. The lodge is right next to Singularity University, where many distinct guests pass by. The building is also fully filled with other NASA interns and internationals during the summer. It was very interesting to hear about other research and stories from people from all over the USA. So many differences between states can be identified and it is interesting to hear other personal experiences.

7. Conclusion

During this internship, many opportunities opened up. Even though I have been working for Code BL, I got the opportunity to work on research for Code A and organize space related events for the ISU interns and alumni. It became obvious that this internship can be as good as one wants it to be.

7.1 UAV Project and International Partnerships

Working on research for the UTM Project, gave me the opportunity to be part of a tremendous research project, offering many opportunities and contacts. With the goal to enable safe low altitude operations in class G airspace, collaborating with the FAA, the outcome will be for national and international benefit.

During the current stage of the project, build 1, most importantly will be to collect the right data and draw the right conclusions. Furthermore, it will be of great significance to partner with the right organizations and offering the right opportunities to other parties.

Considering the current research that is being conducted with respect to the hardware and software integration of different companies, expectations are that the progress to the next build will be conducted smoothly and the technology will allow for BLOS operations. The question is if the FAA will move at the same speed or if the commercial organizations can wait for the regulations with respect to the NAS to change.

The different UAV's will need to be tested for their capabilities and aerodynamic stability. The test maneuvers that were chosen and adapted include the 3211 and the frequency sweep, offering a wide overview of flight data, allowing the project to move forward.

In case of a loss of signal, redundancy is the main solution. Low-cost ADS-B receivers can be on the market soon, enabling a safer low altitude airspace. On board camera's can give a back-up option in case of a lost link, or even autonomous operation and awareness. Swarm intelligence can offer solutions, if the right equipment is applied to all operational UAV's in the same airspace.

7.2 The ISU Space Coast Trip

The planning and management of the ISU Space Coast Trip required collaboration between NASA Ames and companies in the area, giving the participants a good overview of on-going work in the space sector.

The planning of the trip involved a lot of patience and communication, setting clear deadlines and making sure all involved parties were aware of the progress.

Not only did the group get the opportunity to visit world leaders in the space industry, we also got the opportunity to build a strong network including ISU alumni.

Being involved in visits at NASA Ames gave me an inside perspective of what other organizations and countries do and how this ties together with NASA Ames. Ames seems to be one of the more international and progressive centers with respect to research. With 47 active agreements with other organizations, it is clear that the center is open for cooperation and has its hands on several projects at the same time.

Based in Silicon Valley, organizations approach Ames and speak out about possible collaboration. Partnerships is clearly one of the most significant departments at this center and working for this department gave me the opportunity to meet inspiring figures.

Interning at NASA Ames gave me the opportunity to find out more about the 'real' NASA and how things work. Not just the procedures, but also its people. People make the center and I am grateful for being part of the daily routine at Ames this summer.

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