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Organizational Memory: An AIAA Investigation

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Abstract

The AIAA OM project is an attempt to investigate the magnitude and consequences of the organizational memory problem in aerospace. By uncovering promising projects that were left in the oral tradition, we hope to shed light in the issue of how to transfer the experience of the 26% of people retiring in the next few years to those entering the field. The results of the project are that about 20% of our sample of 93 had a story that they wanted to tell. Nearly all of them declined to do so because it involved proprietary or classified information. Only 5% felt at liberty to speak to an AIAA student group about promising leads for the future. This team offers recommendations to the AIAA about how to mitigate the problems we faced in gathering this information.

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Introduction

Organizational Memory is the accumulated body of data created in an organization's history. This includes the combined knowledge and experience of experts and physical record. Organizational Memory is a challenge in many fields as new generations replace old ones, but it is a special problem in fields with stop and start funding where not all projects are completed. Our team investigated the problem of Organizational Memory within the aerospace field specifically as experienced by approximately one hundred of the oldest professional members of the AIAA New England Chapter.

The American Institute of Aeronautics and Astronautics (AIAA) is a community of Aerospace experts and enthusiasts that wish to "address the professional needs and interest of the past, current, and future aerospace workforce and to advance the state of aerospace science, engineering, technology, operations, and policy to benefit the global society."[1] This community contains a wide range of people from students to retirees, not all of whom studied aerospace formally. To figure out the gravity of the problem as well as the opinions of Aerospace professionals our team looked into the AIAA's retired or soon-to-be-retired members.

The project stemmed from the case study of the Propulsive Fluid Accumulator (PROFAC) system. Sterge Demetriates first proposed this system in 1959. Due to the sociopolitical atmosphere of the time, including international tensions and the firm belief within the industry that creation of a nuclear space drive was imminent, the idea was dismissed. A report by Ashish Palooparambil led our team to believe that it was not the only case of an idea being disregarded and lost. In fact, we found ideas were cast aside due to a multitude of causes, none of which were the technical feasibility of the idea. For more about the Demetriates project and further related projects to come,

[1] http://www.aiaa.org/content.cfm?pageid=189

please see the discussion section. We hoped that our work would find that the problem was small and could be easily overcome; however, we expected otherwise.

After obtaining the list of members from the AIAA, we narrowed our search to those strictly in Aerospace and at an age above fifty. Since our problem dealt with the loss of information from passing generations, this was a logical conclusion. We spent the majority of time getting in contact with these Aerospace professionals and asking them for stories of lost data or cancelled projects as well as their opinions on extent of the Organizational Memory problem within the Aerospace field.

Our primary job was to determine the size and nature of the problem. We were also to identify cases that were worthy of a formal presentation to the AIAA NE membership or a student group.

The results of our study, although not the multitude of stories (50% of retirees) we expected, did make it clear that there is an organizational memory problem in the field especially as a significant portion of the field reaches retirement age in the next three to five years. In fact only about 20% of those in retirement had a story they could tell. Some of the rest would have if asked at the moment of retirement, but have since disengaged professionally and are now active in another social technical domain. Many of the 20% with a story worth telling are not at liberty to tell it for a variety of reasons. Since we found out there is a problem, we can pass on the information we obtained to help others better understand how to approach this problem as well as possible solutions to it.

Methods

The project began as an idea; there were several steps that had to be taken and obstacles that had to overcome before beginning substantive work. Most projects do this during the "PQP" phase, however, because there was no PQP the combined workload of the IQP and PQP had to be done in the time constraints of an IQP. In the process of developing the methods needed to accomplish the goals of the project, our expectations for the end product changed. Below are the final steps taken to complete the project. Some of the details of the steps differ from those written in the proposal because of the dynamic nature of the project and projects often evolve in the field.

Project Proposal and Approval (pre project)
Contact List Construction
Idea Recovery and Data Analysis/Final Report

Project Proposal and Approval

The Project started with the overarching goal of determining the magnitude of the organizational memory problem facing the aerospace community. The initial desire was to conduct interviews with individuals who would a case study to offer to the project. It was however, important to gauge the degree of concern about OM in the retiring generation, even if a retiree did not have a full case study to offer. The team planned to record interviews and post them online to advertise the work of the IQP and to provide a source for student chapters looking for local speakers. The team would write up reports for each interviewing case, and finally create a database with the uncovered information. This database will be established provided that there were interesting speakers for AIAA events among the interviewees. All AIAA members would have access to the database.

While writing the project proposal the database idea was cut from the project because of concerns of the quantity of information that may have been discovered and the requirements for

creating and operating a perpetual database. The final proposal (AP1) detailed a more streamlined project.

The project required permission from both the WPI Institutional Review Board (IRB) and AIAA New England Chapter for the purposes of handling "Personal Information" of participants. The IRB exemption form (AP2) is required from all IQP groups whom require data gathering through interviewing of human subjects. Also, AIAA New England required a confidentiality agreement binding the team to a data usage policy. The final terms of the policy were agreed upon in a meeting between the IQP-OM team and the AIAA New England Council.

Contact List Construction

The OM project required us to determine accessible people for possible interviews, contact those individuals, determine their interest in participating in the project, and interview them. As such, this plan required us to reach out to an outside source for assistance in gathering contact information of potential participants. Since we conducted the project with the AIAA, we were permitted to use an article in their AIAA newsletter to spread awareness of our project to their members. With the proper consent, we also used the AIAA New England Chapter Member List as our primary source of contacts.

Before we could receive access to the member list, we were required to sign a confidentiality agreement with the AIAA (AP3). This agreement contained information on how the contact information would be handled, transferred, and used. The agreement was drafted by the project group and approved by project advisor Professor John Wilkes after one revision. The revision specified that the contact information given to the project group by the AIAA would only be used for initial contact purposes, and that upon further contacting individuals, a copy of the agreement or a form describing its contents would be given to all participating individuals.

After obtaining access to AIAA New England member contact lists and their interests, we received two EXCEL files with the information. We then enclosed the files into containers encrypted by TrueCrypt.[2] In accordance with the confidentiality agreement, all file transfers were conducted while the files were secured in the encrypted container. The contact files had important distinguishing information on individuals, but the lists were too large and contained the contact information of some professionals that didn't fit the target profiles we were searching for. We agreed to stay away from spamming the entire contact lists and to be more direct with our contacting however this required parsing through the list and when attempting this next step we ran into a few problems.

Unfortunately, because of software changes made by the AIAA National Office, the two lists were from different time periods and were of different structure. This made the accuracy of the older list uncertain but more importantly it also meant that some of our older professionals could've been on both lists. An additional problem encountered was that one sheet contained each contact's interests but had no date of birth while, on the other hand, the second file contained dates of birth and interests but required a decoding key. At the time we received the files, the interest code description key was missing but we were later able to decipher the codes and filter our contact list.

Considering all of the problems we decided to, prior to cutting down the list, overlap the two and sync them into one coherent list. This would assure every professional's name was listed once and that we would have both D.O.B's and interests on one file making the list more manageable. Unfortunately, the overlapping of sheets meant that some data was inevitably lost.

After combining the lists, we determined the key factors for organizational purposes were Date of Birth, Location, Interest, and Phone Number. We therefore formatted our spread to weigh

[2] http://www.truecrypt.org

these categories more heavily than the others. Finally, we divided the individuals into age groups. These groups were dubbed "younger than 40", "40 to retirement age" and "of retirement age." Initially we focused on calling the persons of retirement age, which left us with a pool of about a hundred people for our first wave of calls.

Idea Recovery & Data Analysis

The technique agreed upon at the completion of the final project proposal for gathering and parsing information was as follows: first, make preliminary contact with the pre-determined individuals, informing them of the project and its aims, and determining their interest in participating. This includes people with a specific story to tell *and* people who simply have opinions about the topic of organizational memory in the aerospace field. Second, follow up with those highly interested individuals and formally interview them to get a solid grasp of the nature of their organizational memory problem. Third, write a formal description about what was covered in the interview. Fourth, select a few speakers to present at an AIAA New England meeting.

During the Initial Calling Phase we took the sorted "of retirement age" list and rearranged this list by city. We did so with expectation that some of the team members would be traveling to the interviewees. It was reasonable to have each member cover a particular area so that we could send one member to a region where he/she could hold multiple interviews. A preliminary script was created to assure that every call followed a similar format and that the team member calling the professional would always collect comparable data from each call. (AP4) After our first round of calls, we later decided to extend the list past the original of-retirement group to include what we had found to be a "sweet age"; between ages 66 to 71. We executed the same initial calling process with our newer calling list. It was also during this time where we collected the counts of who had interest in the project, opinions on the OM problem and stories to tell in order to later represent our results in statistical form.

The Email Phase was our final attempt to exhaust the AIAA list and make sure that those potential participants who haven't surfaced weren't being passed by. We took our synchronized list sorted by interest and we sent one last "hail mary email" to all professionals of the target interest areas who we had not contacted already by phone, and idly waited for a chance at last minute discoveries. In the end, we found that the less direct, more public forms of contact like the group emails and AIAA publications proved to be ineffective methods of searching for participants.

The Follow-Up Phase was a way for the team members to check in with their respective participants via email and/or telephone. The type of contact was left at the discretion of the team member. It was here were we were able to decide whether the contact would participate as a someone with and opinion whom we would give a small section to, as a story teller whom we'd give a case study or as someone with an interesting story whom were potential AIAA presenters. It was also part of the follow-up phase to recall all unreached contacts to make sure we weren't losing potential participants because of the time of day that we typically made calls.

After the calling portion of our project we then moved into the interviewing phase of our project. This phase, simply put, included interviewing of all participants with a story. The beginning of this portion actually started in the follow-up calling phase because it was during this time that the participants were asked to give a brief description of the project that they would share. They were also asked whether or not they were willing to travel to WPI for the interview. We then asked when would be a convenient time to hold an interview. The job of planning the logistics of each interview was solely the job of the team member who had contacted the respective interviewee during the initial calling phase.

The interviews were supposed to have all of the following elements. 1) Each interview would be recorded just in case the content of the conversation needed to be referred back to for any reason. 2) Each interview would have be held in a quiet, predetermined, private area so as not to be

subject to interruptions that would affect the flow of the interview and/or the live recording. 3) Each interview required one or more team members to have with them a list of applicable questions to be answered by the interviewee by the interview's end. These questions were not sequential and could be proposed in any order so not to disrupt the flow of the interview. 4) The bulk of the interview would be a discussion of the cancelled project, the reasons why it wasn't pursued further, and the benefits of the project's completion.

Results

The results of our project will be presented in the same order as the methods section.

Project Proposal and Revision

A big part of discussion in the early stages of our project involved the specification of the project goal. Understanding the question of organizational memory's existence we knew what general question we wanted to answer but were undecided on what we believed the products of the project should be. As a result a lot of our discussion—which assumed we would have a plethora of cases to share—went by the wayside as ideas were proposed and discarded.

The first of many discarded ideas was that of a perpetual database. The team was very excited about the creation of a database because of the value it would have for those looking for AIAA student chapter presenters and those wishing to document their ideas. We quickly noticed that the establishment of a database would prove very difficult. A database would require a lot of writing content and programming to build maintain. Ultimately, we discarded the site for the following reasons. First, we were not sure how many professionals would contribute to the database. Second, we were unsure of who would be maintaining the website after the project was completed. There was no one to continue to add content to the database and no one to moderate new content. Finally, we were unsure of who would provide the funding to operate the website after the funding for our project ended. All together, we decided that the group's efforts would be best focused on locating and interviewing individuals. However, by then a week of time had been spent evaluating the feasibility of the idea

Our second major revision to the project proposal was in the budget section. Because we anticipated significant monetary requirements to conduct interviews in different parts of the country (including Florida, California, and Alabama) we needed a way be sure we could afford the

travel. Our sponsor agreed to a "matching funds" arrangement to guarantee that we would be contributing to travel expenses. We decided that our team would provide the first $250 and would receive $500 from WPI, which the AIAA would match. Unfortunately, because WPI requires the sponsor to contribute before it will, we would have had to contribute funds before any further funds would be contributed. Complications and confusion in this regard, in addition to our lack of contacts in the areas led us to focus our immediate efforts on the New England region.

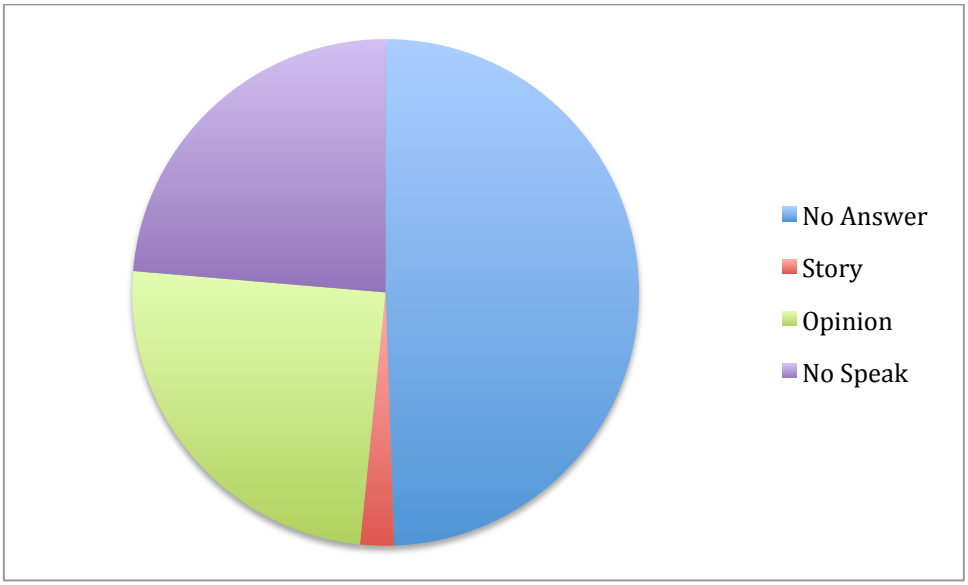
As we worked on the project proposal, the project idea transformed into one which required us to present the project to the IRB. Unfortunately, we did not know about the IRB until the second to last week of A-term. Because of this administrative review, we had to quickly adjust our focus to modifying our proposal into a shorter form that could be submitted to the IRB for exemption. We were rushed because we hoped to submit the exemption form *before* the last week of A-term when B-term IQP's traditionally submit *their* IRB forms.

Contact List Security

In order to secure the contact information in a manner in accordance with the confidentiality agreement, we had to locate an open source, multi-platform encryption program capable of creating an encrypted enclosure. We settled on the program TrueCrypt because it could be used on both macs and PCs and was user friendly. With the data in our possession and an approved plan, we could finally begin making calls.

Calling Phase

During the contacting phase of our project we attempted to contact 93 individuals from the list provided by the AIAA New England. Below is a pie chart of the total number of calls made and the distribution of the results.



No Answer	Story	Opinion	No Speak	Total
46	2	23	22	93
49%	2%	25%	24%	100%

The following descriptions apply to each term used on the chart above.

No Answer: No answer is all people who were contacted either by phone or by email who did not respond. This includes incorrect numbers and email address.

Story: Story refers to all people who responded to the project and had a story or project. These are the individuals for which case studies are being written.

Opinion: Opinion is all people who responded to phone calls or emails and had an opinion about the OM problem. This includes people who contributed enough information to write a "member comment" paragraph in addition to those who felt uncomfortable sharing information about their experiences.

No Speak: This group is all people who answered phone calls but did not want to speak to us at all. This may have been because they felt they had nothing to offer and had no opinion, or because they simply did not want to participate.

The "Opinion" group can be separated into three groups of contact profiles. The first, were those contacts who had an opinion on the OM problem but had no relevant story or idea that they saw worthy of a case study. The second group, were those who had an opinion and a story to tell but didn't feel comfortable sharing it with us—possibly to protect someone's reputation. The final group represents those who felt like they had a relevant story but were unable to share due to formal security or confidentiality restrictions.

Sorting the calling list by city turned out to be of no consequence. The small number of individuals willing to be interviewed meant that the effort to lump interviews in one location was unnecessary. In addition, both of the two individuals on the list who had stories were *willing* to drive to WPI themselves to be interviewed on campus—this will be discussed further at a later section.

The initial calling phase presented several challenges with regards to making calls. Because we did not have access to a single landline we had to determine the best way of making the calls. The two primary sources considered were individual group members' cellphones, and Google Voice on the computer.

The advantages of using personal cellphones were numerous and included the ability to make multiple calls on one's own time. We also found that the sound quality tended to be superior on cellphones. Unfortunately, using personal cellphones also presented some disadvantages. First, everyone had a limited supply of minutes to spend each month. This required us to budget our calling time wisely. Second was the fact that we would be using our personal numbers and revealing them to individuals we did not know. This is an issue of personal privacy that we all agreed to accept in order to complete the project. The final disadvantage of using our cellphones was the fact that three out of the five individuals making calls did not have New England area codes. In fact, two group members had area codes in New Mexico and one in California. We were concerned that the remoteness of the area codes might lead possible interviewees to ignore our calls.

We considered Google Voice because of the ability to set up a general account in the name of the IQP-OM group, using the IQP-OM@wpi.edu alias as a reference. This number could have a Worcester area code. In addition, because Google Voice was offering free, unlimited calling via computer, we could make all of our calls without using any of our personal minutes.

In the end we decided to use our personal cellphones on all but 5 test calls because the higher sound quality and the ability for multiple persons to make calls at once.

The next challenge presented by the initial calling phase was timing for the calls. Despite the fact that a lot of the people we were calling were past retirement age, many of them still either worked for, or consulted with companies in industry. This meant that there was only a short period of time when we could make calls and effectively reach them. The time commitments of the contacts coupled with the fact that many of the group members had other class obligations during the day reduced that effective time period even further. Upon making our first wave of calls, we determined that the best time to make the calls was between 1:00pm and 3:45pm on the weekdays. We believe that the effective calling time was bounded by lunch between 12:00 and 1:00, and the end of the workday between 3:45 and 5:00

As was stated in the methods section, we prepared a script to use during the initial calling phase. We found that the script was not as effective when followed word for word when it was used as a reference to make sure that important points were covered in discussion. During the first wave of calls, we experienced some difficulty speaking coherently because we were trying to fit everything that the script said into the natural discussion. As we became more comfortable with making the calls, we found that the script was a helpful reminder of important topics that needed to be covered as well as a source of specific phrasings of terms.

The first wave of calls completed was important because it was somewhat of a diagnostic of the proposed methodology. Lessons learned from the first wave of phone calls were applied to every other group of calls we made. This includes the effective range of people to contact. During our first wave of calls we found that the number of people who answered the phone and expressed interest in the project or participating greatly rose when they were between the age of 66 and 71.

We dubbed this range of ages the "sweet age" and focused our efforts on contacting people of that age—though we did not exclude people outside of it.

Initially when we designed the calling list, we only called people with astronautics related interests. When the number of interviewees interested turned out to be less than we expected, we had to choose between two different scenarios to expand the list of contacts. One choice was to try to expand our project to other AIAA sections, starting with the Connecticut Section. We considered this because we felt that expanding to another *section* might give us a higher success rate in finding interested individuals. We chose not to expand into the Connecticut Section because of the fear that we would encounter the same red tape getting access to contacts as we did during A-term. Because B term was coming to a close quickly, we needed to be sure that we had access to the new candidates immediately. The other choice was to include AIAA NE members with aeronautics interests to the study. This turned out to be the best plan because of the interdisciplinary nature of the AIAA. An individual's area of interest in the AIAA's database is not necessarily the area in which they worked or studied. (See the recommendations sections for more details.)

Another issue we encountered when making the first wave of calls, which is discussed briefly in the recommendations was the quality of the list. Both of the lists given provided by the AIAA were somewhat dated—at least two years old. Because of this, we had a significant number of people whose contact information was completely incorrect. In one situation a group member contacted a household in which the AIAA member had died.

During the course of our phone calls we found that there were a few main reasons why individuals did not want to or could not participate in an interview. The biggest reason why people did not request to be interviewed is because they felt they had nothing to offer. Although we tried our best to explain the project to the contacts, it is fair to assume we lost a few contacts to people who did not fully understand the premise of the project.

Another reason why people declined to participate in the interview portion of our project was because the material and technology they worked was either classified or proprietary. We did not adequately consider or anticipate the effect this would have on the project. This was the most difficult part of the project to accept, because, in these cases, the individuals clearly had something to offer. The main thing that prevented them from participating in the project was their fear that it was unprofessional, inappropriate or illegal to do so without authorization. From some of these cases we got general expressions of concern and endorsement of the project, but nothing that could be turned into a formal case study as with PROFAC.

The group made two different attempts to garner interest through the use of email. The first attempt was through the AIAA newsletter sent out to all AIAA members. A short description of the project and contact information was written up and posted to the newsletter *before* we had access to the contact lists. We hoped to get at least a few interested parties from the newsletter. Unfortunately, the newsletter netted no interested individuals. We believe that the newsletter had no results because of the small percentage of people who read the newsletter in the first place.

Follow Up Phase

The final "hail mary email" attempt discussed in the methods section was sent in response to the significant number of people whose phone numbers were incorrect on the contact list distributed by the AIAA. We compiled a list of people who we called but did not get in contact with, and who we thought were likely to be sources of information (i.e. within the sweet age) and their email addresses. We sent a generic email—only slightly modified in some cases—about the project and what we were looking for. In this case, one reply resulted in one interested person.

One use for the follow up phase was sending "further information" to people who we had spoken to, but who had declined to make an immediate decision about their participation. These people were individuals who received more information about the project via email. Unfortunately,

we found that none of the people who asked for more information actually decided to participate. Initial reservation indicated concern that ultimately led to avoiding the issue.

The follow up phase was also important in establishing the interview done with James Fraser. During this phase, group members with interviewees contacted them for a second time either by email or phone. The group member associated with the participant determined the nature of potential contribution, and tried to asses the interviewee's interest in participating in the project. Group members set up interview times with candidates who wanted to be interviewed. As said before, the two people who wanted to be interviewed for the project offered to come to WPI. Clearly those who were interested in participating in the project felt strongly about the value of their involvement. They had a story to tell and wanted the next generation to hear it.

NIAC

Towards the end of the follow up phase, the team realized that the wealth of interviews that we had been expecting were not coming, and that further research would be needed to make up for the lack of interviews. In the following weeks, the group began researching the NASA Institute for Advanced Concepts (NIAC), a program that had been shut down in 2007. The cancellation of NIAC provided a golden opportunity to look into organizational memory issues facing the current generation of engineers.

NIAC was a program set up by NASA to find revolutionary ideas that were not yet feasible, but should be researched by the next generation of engineers and scientists. NIAC provided preliminary funding to get these ideas off the ground and bring them to the attention of aerospace companies. During its 9 year run time, NIAC processed over 1300 proposals for funding. It awarded 126 phase I (6 months, up to $75,000) contracts and 42 phase II (2 years, up to $500,000) contracts.

Nearly 25% of the phase II contracts, as well as many of the phase I contracts have gone on to receive additional funding from NASA or the private sector.[3]

These projects are of interest because they indicate good organizational memory. The idea migrated from the project where it originated to somewhere where it could be looked into further with little information lost. Two projects in particular received a substantial amount of subsequent funding: the space elevator (>$8.5 million) and the Moon and Mars Orbiting Spinning Tether Transport (>$3.4 million).[3] The space elevator is quite literally an elevator into space, based on a long cable that is secured on one side to earth and on the other side to an orbital mass. A cart could then mechanically climb its way up the cable into space, drastically reducing the cost to deliver a payload into orbit.[4] The MMOSTT is a structure that would move payloads from low earth orbit up to geosynchronous orbit, from GSO to the moon, or from the moon to mars. It consists of a spinning tether which would catch a payload entering its orbit, then release the payload half a rotation later, thereby transferring some of the structure's own momentum to the payload. The tether would then boost itself back up to its original orbit by creating a magnetic field that would repel earth's magnetic field, pushing the tether.[5]

The space elevator idea was proposed to NIAC by physicist Bradley Edwards, who wrote a book about the elevator as his final report to NIAC. The MMOSTT was proposed by Dr. Robert Hoyt, and was accompanied by a 336 page final report detailing many aspects of the device.[5] Contact information for both of these men is easy to find. Edwards' email address is on the cover of his final report to NIAC, and the email address for Tethers Unlimited- a company that Hoyt co-founded- is posted on their web page.

[3] http://www.niac.usra.edu/files/misc/NIAC_ROI.pdf
[4] http://www.niac.usra.edu/files/studies/final_report/521Edwards.pdf
[5] http://www.niac.usra.edu/files/studies/final_report/373Hoyt.pdf

Unfortunately, such fantastic documentation is not available for all of the NIAC contracts. Some of the final reports are as short as 15 pages, and do not go into details at all, merely stating that certain things are feasible or not.

If one of the phase I projects that did not receive additional funding was suddenly picked up again, it is unlikely that much of the previous research could be utilized due to the lack of documentation accompanying it. This means that any research that was not sponsored by NASA or the private sector upon the termination of NIAC is useless. Even if all the data from these projects is still preserved somewhere, it is unlikely a future researcher could find it. Our team attempted multiple times to contact former NIAC leadership, and could not reach them. Any research team looking to pick up any of the projects that lost funding will probably have so much trouble locating the lost documents that it will not be worth their time. In a few cases, NIAC did a spectacular job preserving organizational memory than our team expected, but aside from a few stellar examples, they did a fairly poor job of preserving and passing on the information that cost NASA millions of dollars.[3]

Interviews and Follow Up Interviews

The interviewing portion of the project turned out to be quite difficult particularly during the wintery season between B10 and C11. The emails discussing interview times were sent during the weeks of B term. This meant that there was downtime during the last couple weeks of B term and throughout the winter break. During C term, two major snowstorms and several minor ones interfered with scheduled interview times. By the time the first interview of C term took place over one week had already elapsed.

The James Fraser interview was originally scheduled to take place on January 18th 2011. The interview was delayed because of a snowstorm and took place on January 20th 2011. It was the intent of the interviewer to conduct the interview in the WPI Gordon Library in a Tech Suite,

however, Dr. Fraser was unable to find visitors parking on campus. Unfortunately, due to the plowing, all of the visitor's parking spaces were either taken or covered in snow. Because of this, the interview took place at The Bean Counter on Highland Street. The loud environment of the Bean Counter prevented the interview from being recorded. Instead, the interviewer took hand notes and many technical details were lost.

In order to make up the lost details of the Fraser interview, a second interview was conducted. This interview was done on the phone using Google Voice. Because the interview was conducted on the phone, Google Voice was the best choice. The entire interview was easily recorded and is available with the report. This interview was important because it filled many of the scientific gaps in the report. It was also much easier to arrange and execute.

Case Studies and Literature Review

AIAA-Organizational Memory Interview: Dr. James Fraser

On Thursday, January 20, 2010, I interviewed Dr. James Fraser of Acton Massachusetts for the AIAA Organizational Memory Project. This report on the interview will provide an idea of the specific project Dr. Fraser felt was promising and did not receive the attention required to reach its full potential. It will also detail other projects he felt were examples of organizational memory success. Finally, it will contain opinions on organizational memory as a whole and solutions to the problem. From this report, and with the approval of Dr. Fraser, the AIAA New England Chapter will hopefully have an exciting new speaker to provide inspiration to other AIAA members. The ultimate goal is to find the most effective way to pass information about promising "loose ends" from the retiring generation to incoming college-age professionals.

About James Fraser

James Fraser studied physics at UCLA from 1961 to 1969 in the days of the great John Wooden. While he was in school, he spent time with and made many friends of students within the engineering field at the school, however, he himself never took an engineering class at UCLA. His education at UCLA included a Bachelor and Master of Science in physics, and a PhD with specific focus on "cryogenic quantum mechanics." His study of cryogenic quantum mechanics focused on very cold metal and helium.

Approximately three years after graduating from UCLA, Dr. Fraser secured a job with Hughes Aircraft in the Advanced Technology Department of the Electro-Optical Division. While working at Hughes Aircraft one of the dozens projects that Dr. Fraser oversaw involved Infrared Sensor Technology—it was within this line of work that he encountered the piece of technology that was the basis of our interview.

Lead-Tin-Telluride Detector

During the interview, Dr. Fraser explained "the most difficult part of making an infrared sensor is making the infrared detector." The infrared detector is a "solid state device" that will "react to infrared radiation."[6] Although many different materials have the capability of detecting infrared radiation, "trade-offs are always being made," and as a part the process of determining the most effective material, Dr. Fraser oversaw research and development of the detector material known as Lead-Tin-Telluride (PbSnTe).

While PbSnTe was more easily manufactured, it had high dielectric constant with resulted in a longer temporal response time, which was disadvantageous use in the dominant sensor configuration of the time. At the time of PbSnTe's development, video images were captured using a single column of detectors, which swept from side to side creating an image. In order to display a video, the detectors had to sweep across the screen within fractions of a second. As a result, the detectors had to be capable of responding to the input very quickly—i.e. the detectors needed a *short* temporal response time. On the other hand, HgCdTe had a lower dielectric constant and therefore a shorter temporal response time. Because of this, HgCdTe was more effective in meeting the immediate needs for IR sensors.

In 1978, Dr. Fraser left Hughes Aircraft and began working at DARPA where he stayed for approximately five years. During his time with DARPA, research continued on the lead detector at Hughes Aircraft Company and several research organizations internationally. Researched continued until around 1979-1980, when the immediate advantages of HgCdTe and the apparent fundamental disadvantages of PbSnTe lead the U.S. Army to drop all funding for development of the lead based detector.

[6] http://en.wikipedia.org/wiki/Infrared_detector

In the time since Dr. Fraser initially worked on the PbSnTe detector, advances in detector readout integrated circuitry (ROICs) and silicon device technology for video imagers and military surveillance systems have brought renewed use to the lead compound based detector technology. Five years ago, Fraser realized that, with the new electronically scanned detectors arrays (also called focal plane arrays) readout rates would be hector-hertz instead of tens of kilohertz, eliminating the temporal bandwidth limitation of high dielectric constant materials like PbSnTe. Approximately 5 years ago Fraser, working as a contractor support scientist at the Missile Defense Agency recommended that PnSnTe be revisited as a better alternative to HgCdTe. Funding was provided but in the absence of rapid progress development was dropped after a little more than a year.

Doped Silicon Detector

Fraser also gave other examples where he felt organizational memory was lost. One of these other cases included work he oversaw on "doped silicon detectors," also used to detect infrared radiation. Doped silicon detector technology was effective and satisfied a specific range of the government's needs, but also required much cooler operating temperatures than other materials. Doped silicon was more expensive to operate outside of the laboratory environment. In addition, nearly impossible to support the required cryogenic cooling requirement to operate the focal plane array in a satellite-borne sensor. Limited funding compelled Fraser and other managers to drop the silicon detector work in order to concentrate on HgCdTe.

After research in doped silicon detector technology was discontinued, the government found that the increasing need for the specific capabilities of the doped silicon detector made the research once again worthwhile. In the process of developing the material for the second time, the government had to "go through the entire learning process again" to recover lost ideas. Researchers

had to learn how to grow the material correctly to attain the desired properties. This loss of organizational memory significantly set back the development of the technology.

Gallium Arsenide

The final project that Fraser discussed was work he did on Gallium Arsenide (GaAs) research. This project however, was a success with very limited organizational memory problems. Fraser worked on gallium arsenide research while at DARPA but stopped work before the primary hurdle with the technology could be overcome. Gallium arsenide is useful as "microwave transceiver on a chip" and is now used in cellphones.

While Fraser worked on GaAs technology, he was tasked with determining how to achieve practical manufacture commercially viable amounts of the material for use in microwave integrated circuits. At the time of his research, many people doubted if it would ever be possible to manufacture large pieces of pure gallium arsenide. These doubts lead to an initial skepticism from the microwave community that this goal could be reached and industrial funding would be viable. Only due to perseverance and persistence from several industrial research companies did the technology rise to a technology readiness level (TRL) that allowed for commercial development. (AP5)

As a result of his work on GaAs technology, James Fraser with 14 other scientists were inducted into the Space Technology Hall of Fame—a Space Foundation program in 2003.[7] To Fraser, this is a situation where organizational memory was preserved perfectly.

General Opinions on Organizational Memory

Near the end of the interview, I asked Dr. Fraser if he had any general opinions on the organizational memory problem. He stated that although he does agree the existence of the

[7] http://www.spacetechhalloffame.org/inductees_03_Monolithic_Microwave_Integrated_Circuit_Technology.html

problem there are some safeguards in the form of "corporate memory" in Federally Funded Research and Development Centers (FFRDC's) to help mitigate the problem. Places such as MIT Lincoln Labs, The Aerospace Corporation, and several other academically based institutions such as the Utah State University's Space Dynamics laboratory and the Georgia Tech Research Institute (GTRI) provide a place for researchers to develop basic technologies to more feasible commercial levels. Despite this, He did mention the case of the second engine being developed for the Joint Strike Fighter as a possible future example of organizational memory loss. Fraser feels very strongly that the government has a certain responsibility to maintain a national capability in complex aerospace technologies such as engine manufacturing. Canceling a project like the F136 engine risks wasting sunk funds and loss of critical skills.

Follow Up Interview

A few weeks after the initial interview, I conducted a follow up phone interview with Dr. Fraser. Fraser discussed more details about the mathematics and science behind the detector technologies. This discussion clarifies many of the specific details that were simplified in this report. To listen to the interview play the attached mp3 file.

Conclusion

To conclude both the interview and its part in the project, I asked Dr. Fraser if he would be interested in giving a speech on PbSnTe development. While Dr. Fraser "was not directly involved" in development, he expressed interest in giving a speech on the technology. He seemed particularly interested in speaking to WPI students who could possibly be involved in the future development of sensor technology. While responding to the question, Dr. Fraser said "in some ways the fundamental physics are being ignored by researchers today. That's too bad." It's quite clear that Dr. Fraser believes there is an organizational memory problem looming in fundamental development of sensor technology.

Literature

Unfortunately, because of the nature of the technology and its Department of Defense funding, access published literature and technical details of the PbSnTe infrared detector is limited. However, Dr. Fraser did say that reports from SPIE meetings, which can be found on the SPIE website[8] and many trade publications could provide AIAA members in academia and industry access to the important elements of research done on the technology. Other possible sources given by Fraser include various "journals specializing in infrared research" and books that could be of use to an interested student or professor. Finally, Fraser directed me to work done by the Military Sensing Symposium (MSS)[9]. To view the list of open references on IR sensing technology from Dr. Fraser, please see the appendix of the report. (AP7)

[8] http://spie.org/
[9] https://www.sensiac.org/external/index.jsf

Entering Space: Creating a Space Faring Civilization

Earth's moon. It orbits around earth and over the heads of billions of human beings every day. It's no wonder why the aspirations of the personnel of the Apollo era aerospace industry were inspired by this mysterious rock. There was not a lot left to discover on our planet. The excitement from the hopes of reaching a new frontier was enough to fuel the creativity and innovation of aerospace professionals. The challenge was enough to try the skills of our industry which lead to further advancement in aerospace technology. It was one common objective that kept the aerospace industry on a path to success.

In his book, Robert Zubrin advocates that our current industry is in need of new objective. He points out the fact that during the more productive Apollo era our industry created "the entire bag of tricks that enables space exploration today." He continues by sharing an extensive list of technologies that were all developed between 1961 and 1973. He points out that the government spends nearly $16 billion per year on NASA—a budget within 20% of the funding given in the Apollo era—with far fewer technological advances.

Technology allows for progression of society and we seem to create more technology when we are troubled by stresses. Zubrin states out two stresses in particular. The first being war stresses which causes warring parties to worry about weapon technologies. The stresses of war have brought many important developments to the aerospace industry. In recent years, wars have had a decreasing role in funding aerospace endeavors.

The next important stress is "frontier shock," which forces migrants to create new technology to adapt to new environments. The Apollo program is an excellent example of frontier shock. Zubrin believes that, if placed under this stress, our aerospace industry once again can produce work at a rate comparable to the Apollo era.

Without groundbreaking goals, the aerospace industry lacks the means to develop effective spacefaring technology. It was the ubiquitous mindset to reach the moon that allowed for engineers to be free and daring with design during the Apollo era. Many engineers no longer have that luxury

When working for Martin Marieta, Zubrin devised a way to improve the Titan rocket while cutting the production cost in half. When he proposed the idea to management it was shot down. The manager told him "If the Air Force wanted us to remake the Titan they would pay us to do so." Similar situations are found throughout the industry where good ideas are tossed aside because of 'company interest'. The truth is that the government pays all aerospace companies with an agreement referred to as "cost plus". In this agreement, companies only specify the cost of development, not the end cost of the product.

While this method of business removes the risk and competition that is essential to capitalist system, it also undermines the drive to develop new technology. How can we improve organizational memory if the only people who care about the project ideas are the innovators?

Pax Mundana is a term used in two of Zubrin's books. It defines a complacent society that becomes stagnant after a long period of laborious ascent. Throughout history we can recall a trend of "crystallized" empires falling because of the tendency to isolate and stagnate. The Ming Dynasty, Roman Empire and Ancient Egypt are all examples of this. So what happens now? Do we continue down a similar path and wait until an inevitable problem is upon us? It is for all the aforementioned reasons that Zubrin believes that a new objective is needed. He believes interplanetary colonization should be the new goal of the Industry.

In the 1990's there was much talk about making systems single stage to orbit (SSTO) to replace the current multi stage systems. Zubrin's aircraft design was called the "black colt" which was a spin off from a previous design that inspired the colt. Until then, SSTO's were designed with vertical takeoff vertical landing (VTVL) techniques but the colt had a Horizontal Takeoff Horizontal

Lift (HTHL) procedure. The important advantage of HTHL was that it was similar to that of a traditional aircraft and therefore could be used on a standard runway.

If this idea could be implemented then we could produce a vehicle capable of reaching LEO that would have variable usage including travel, package delivery, and military operations among others. Modifications could be made to serve the specific needs of all potential business partners. This technology could single handedly change the face of spaceflight.

This idea is all good and well but a lot of different challenges come with creating such a system. Getting systems into space requires a lot of fuel, limiting the maximum allowable payload. The newer technology would have to account for enough fuel to get to orbit and supply enough thrust to change the impulse of the rocket when changing orbits. Zubrin suggests that refueling the spacecraft would be the most effective way to do this.

To create an SSTO, other new technology was necessary. That included landing gear, reentry thermal protective systems, and maintenance requirements. Many of these issues were addressed with the space shuttle program. The landing gear would be necessary for such a universal system.

So what happened to such a great idea? In 1994 NASA announced a competition for the design of the X-34, a reusable launch vehicle similar to the black colt. Upon hearing about the black colt, NASA offered Martin Marietta what Zubrin estimated to be 83% of development costs to produce the colt. When Zubrin brought his concerns to management he was told "Look Bob it's a very clever idea, but you've got to get the picture. We build Titans and if you sell one of these to the Air force then we're out of business."

Member Comments

Multiple persons were contacted who agreed with the premise of the project, and agreed that an organizational memory problem exists. Some of these people declined to speak due to the secret nature of their work. Others declined for different reasons. Some of the times, those individuals provided some opinions about the magnitude and possible solutions to the OM problem.

Contact 1 works primarily with inertial navigation systems, specifically flight code and design testing. He has conducted work for deep space probes and unmanned subs. He declined to speak with us because of the secret nature of his ongoing work, however he did agree that the aerospace community faces a OM problem. He did not give any suggestions for solutions.

Contact 2 works on guidance systems specifically for space vehicles. However, he was reluctant to speak on the specifics of these projects, most likely due to the sensitive nature of the material. Although he did not want to participate in the project, he did say that he agreed with the project, mentioning that frequently, projects are canceled due to lack of funding. He did not mention any possible solutions to the problem.

Contact 3 did not provide information on his current area of work; however, he did give a descriptive assessment of the OM problem and methods of handling it. First and foremost, he agreed that the problem existed and was a significant one. He spoke specifically about reporting and monitoring techniques. He spoke about writing reports about "quick fixes" in the field and otherwise. He also spoke about report writing for the review and recollection of ideas. Contact 3 described the computer as a useful tool in recording data and ideas. Contact 3 also spoke of mentoring as a way of keeping ahold of organizational memory.

Contact 4 was involved in the Iridium Control Center orbit management software development task at Draper Labs. The Iridium System was proposed as a constellation of over 70

satellites in near polar circular orbits at an altitude of approximately 750 kilometers. In 1994 there was a competition for the contract. In the end the contract went to McDonnell-Douglas in Houston Texas. The contact believed Draper won the overall technical contribution, but lost financially, and believed many ideas were lost during this time. Overall he agreed that there was a problem with organizational memory and was willing to speak about his time at Draper. He felt that he had numerous cases stemming from his work that would fit with our project. Unfortunately due to bad weather and prior obligations, the interview never occurred.

Discussion

We approached the project with open minds as to the magnitude of our findings. It would be unfair however to say we did not have the slight expectation that we would find a significant number of retirees who wanted to tell their stories. Quite frankly, we expected a very large number—enough in fact, that we expected to be overwhelmed with the number of cases from which we could choose. Clearly, we expected the number of cases to represent a large proportion of engineers retiring.

At first the group was disappointed with the findings. Being science and engineering students, as we are, our obvious interests lie in the stories we hoped to find. How could people be so disconnected from what, at one point, was such a significant part of their lives? How could individuals who put so much effort into their careers and ideas just move on and not look back? This was probably the most stunning finding of the organizational memory project. Clearly, these retirees must have reached a sense of hopelessness in the belief that their projects would be resurrected or redeveloped.

After a while though, the group realized that there was more to be uncovered than just the inability to draw the interest of dozens of retirees—like we had originally hoped to do. We realized that getting interviews was really just the icing on the cake. The important lessons of the project were not actually in material uncovered, but in techniques and methods used for mediating and understanding the organizational memory problem.

One example of a finding that will undoubtedly prove extremely useful to anyone interested in organizational memory is what we called the "sweet age"—a range in which individuals are more likely to be willing to tell about their OM case. This is important both to the aerospace industry and every other industry that experiences the OM problem. Perhaps the age range is not the same, but it would clearly not be a stretch to say that every industry that has an organizational memory

problem has a "sweet age" range. By knowing what the "sweet age" is for the industry at question, efforts can be better focused to control the problem.

Another interesting finding was that the few people who wanted to participate in the project were extremely enthusiastic. In every situation, when an individual had a story to tell and was in a position to tell it, they were more than willing to travel to WPI to tell that story. In many of these cases the people who felt the idea was promising had some influence on their cancellation in the first place. The Fraser case is an example of a manager being part of the decision to cancel a project, and then attempting to resurrect that project at a later date. Because managers see many ideas and the big picture around them, they are better able to assess to potential of those ideas in light of current technology. With that, they are also better suited to recall past ideas and bring them back to light when new technology makes those past ideas more feasible.

The last finding draws an interesting connection to the case that inspired our project—the Demetriates PROFAC case. We found the Demetriates case to be an anomaly. Perhaps it is because Demetriates was the person from whom the project idea originated, whereas the people who communicated with simply us told stories of projects they participated in. In the PROFAC case, Demetriates experienced alienation and harassment from the US government. He felt that the US government was trying to control him and his idea. This experience caused him to disengage himself from the community, though still felt strongly about the idea.

The good news is that we found the PROFAC case *was* an anomaly. People don't feel like good ideas are intentionally being cancelled or scrubbed. Most people feel and understand that economics is the driving factor behind most aerospace and defense funding, and that cuts and cancellations will always be made. However, PROFAC is not the only case in the literature that is disturbing. We find the Zubrin Black Colt case and the NIAC meltdown equally upsetting. There is a problem to address and it may be too big for the AIAA to tackle—let alone a single AIAA chapter.

Conclusion

We went into the project expecting to find a significant percentage of professionals who had a story to tell. The large number of aerospace/defense projects that are cancelled annually seems to *imply* that there will be a large number of scientists who have an organizational memory case. We believed that despite the obvious issue of technology being secret and/or proprietary, there would be a large percentage of cases that we could discuss and document. Our assumptions were incorrect.

At face value, the main conclusion drawn from this project would be that there in fact is *not* an organizational memory problem. The numbers are simple enough. Out of nearly 100 people contacted, only 2% was willing to be interviewed. Even looking at the 25% who had an opinion on the matter, one would logically conclude that the OM problem is limited at best. However, upon further inspection, one comes to a few important conclusions.

The 25% who had an opinion was approximately 50% of the total phone calls answered. This statistic shows that the organizational memory problem clearly larger than the small 2% interested in speaking would lead us to believe. Any attempts to delve further into the OM problem will clearly need to have more accurate contact information to create a larger sample source. Having said this, we do know that some of the people who did not answer the phone or their emails did not do so because they were not interested in participating in the project. One can only speculate as to their reasons not to participate.

There were significantly fewer individuals interested in participating when they were out of our "sweet age" range. When we returned with the results from our first round of initial calls we were surprised that these professionals who had worked in an industry for a grand portion of their lives could just shrug off an opportunity to speak to the professionals entering the field. We thought this might've been a matter of change in focus of the retirees' lifestyle. When someone retires and

they start to find other things to fill their time they start to drift farther and farther away from the aerospace industry. Having said this, the results of this study cannot contribute to a conclusion on why some professionals prefer to work simply as consultants while others decide to completely leave their profession behind and move on with life. This project *can* help develop a conclusion about the percentage of people whom we were able to get in contact with. Of those people, again, nearly 50% of them had an opinion on the OM problem. This number is far closer to the number of people we expected to find were interested in our study. It can also help us develop more effective methods for drawing information from the people we do get in contact with. If we focus on and encourage participation from people in our sweet age, we are likely to obtain a more accurate estimate as to the magnitude of the OM problem.

We also found that people who had a story to contribute were extremely interested in participating in our project. In many cases, they were more than willing to come to WPI to participate in the project. By taking advantage of this fact in addition to our knowledge of the sweet age we believe we can significantly increase the participation in the project

Ultimately, the project found that though the organizational memory at face value may seem minor, it actually presents a significant problem to the industry. Engineers and managers alike are concerned about what will happen to projects and ideas that don't get fully developed. Unfortunately, the means to mediate the problem are not as simple as hoped for. It seems that the very nature of the technology being developed for the aerospace and defense industries lends itself to organizational memory problems. As such, it is in the best interest for companies to attempt to control the problem within their rank. Having said this, it is clear that there is need for an outside foundation to recover lost technology from those individuals who no longer have association with a specific company.

Recommendations

Our work on the Organizational Memory project has led us to believe that, although the OM problem is not as widespread as we had originally thought, it still exists within the AIAA community. Despite the relatively few number of case studies ultimately drafted, we found that there were more situations in which an OM problem existed than were documented. It was this important conclusion that marked the end of the first AIAA OM IQP. As a general statement, if the AIAA New England so desires to continue investigating the OM problem, it should do so taking into strong consideration the recommendations below.

Although the results of our project were not what we anticipated, we learned many important lessons and are confident that the study could be done again if the AIAA NE so desired. Many of these procedural recommendations will be most useful if applied to IQPs similar to ours. We make these recommendations assuming that the general project idea has already been presented to the sponsoring agency or corporation before taking any of these steps. This fits well with the IQP scheme because students generally sign up for a project during the spring of their sophomore year, and complete work during their junior year. As such, sponsoring needs to be confirmed *before* the start of the project. Data collection time should not be lost due to lack of organizational approval in advance.

Our first recommendation is that, any group wanting to do research into the OM problem, establish their relationship with the sponsoring company or foundation before starting the project. Included in this process is determining how funding—if necessary—will be provided to the group. It also includes establishing whether or not the group will be working as *members* of the sponsoring group or simply as representatives. Having said this, we found and recommend, for simplicity, that the group be considered to be representing the company/foundation. This is our first recommendation because the relationship between sponsor and group influences the tone of the

project proposal. Also included in this process is preparing formal confidentiality agreements between the sponsoring group and the researching group. This first step allows the project group to work through any red tape involved with having a sponsor *before* beginning formal work on the project.

We believe that the project would have benefited from an association with a Federally Funded Research and Development Center in addition to the AIAA. There are a few reasons for this. First of all, the FFRDC would have a vested interested in the success of the project. Uncovering potentially game-changing ideas could result in increased federal funding for the facility. Second of all, the group would have access to a larger contact database. This would likely net a greater number of interviews. Finally, we believe that employees of the FFRDC would feel more comfortable discussing projects. This final point is very important because of the large number of people who declined to speak to our group due to privacy concerns.

Our next recommendation is that substantial pre-project research be completed—as with projects done abroad. It is important to determine what work—if any—has been done regarding the OM problem. By conducting preliminary research, the project group can find other people who are closer to the root of the problem to provide opinions. In our case, we hoped that NIAC would fill this role. Failure to fulfill this part of the project can result in unnecessary grunt work. By conducting the pre project research, the group can evaluate the end products of an investigation into OM and determine what end goal is appropriate for their case. It is important to establish a concrete ending point for the project before beginning.

If a project proposal cannot be completed during the PQP then a date should be agreed upon for group members to meet with sponsors and get final project approval. Because of the heavy reliance on sponsors for contacts, having approval from the sponsor early on will lead to quicker and more efficient research. It is important to take all possible precautions to prevent a delay in an

approval meeting. In addition, we recommend that upon presentation of the first draft of the project proposal, IRB guidelines be reviewed and—in similar cases—an IRB exemption form filled out.

If the primary group of interviewees is multidisciplinary, we recommend that there be no distinctions made between interests when deciding whom to contact. This is important for two main reasons. First, organizational memory occurs in all fields. The fact that a potential interviewee may not have a desired primary interest should not change the value of their opinion. There is no guarantee that a person's area of interest is where their organizational memory failure experience may have occurred. By discriminating based on interest area we cut out a group of potential interviewees.

Our final recommendation is that the project group be smaller. Our project group consisted of five people. This made communication and meeting together as a whole group very difficult at times. In addition, the quantity of work required for the project was not such that five group members were necessary. The large group size made most project work very inefficient. A group size of three members would be ideal.

Acknowledgements

Professor John Wilkes: Our team would like to show our deepest gratitude for Professor John M. Wilkes for his unending support and guidance, and for his role as an advocate for this project with the AIAA.

Dr. James Fraser: We would also like to thank Dr. James Fraser for his participation in the project. His interview resulted in revealing and interesting case study, which contributed greatly to the results of this project. We hope to arrange a presentation soon, so that Dr. Fraser can present his results to the next generation of physicists and engineers here at WPI.

Natasha Peake: We would like to thank Natasha Peake for her contributions to the project from start to finish. From the initial proposal, the calls she made, and her study of the PROFAC case. All of her contributions were key in making this project a success. As stated in the background section, more is to come regarding the PROFAC case and Sterge Demetriates. We look forward to seeing what Natasha's work will produce regarding that matter—we are sure it will make a interesting addition to the conclusion of our project.

AIAA New England Chapter: Finally, we wish to thank the AIAA New England Chapter for sponsoring the project. The AIAA New England Chapter's contribution of member contact information was essential in the completion of the project. We hope that the results of the project presented in this report will help the chapter understanding the OM problem facing its community. We also hope that the results of the project will help the AIAA NE develop methods to mitigate the Organizational Memory problem within ranks. It is our sincere hope that the proactive behavior on the part of the New England chapter to address the OM problem becomes a model for other professional organizations.

Appendix

Ref. #	Name	Description
AP1	Project Proposal	Final Project Proposal to AIAA
AP2	IRB Exemption	Exemption Form issued by IRB to IQP-OM Group
AP3	Confidentiality Agreement	Confidentiality Agreement to AIAA
AP4	Calling Questions	Questions written for preliminary calls
AP5	TRL Chart	Chart describing TRL scale
AP6	J. Fraser Photos	Photos of technology referred to in J. Fraser interview
AP7	J. Fraser References	References on IR technology from J. Fraser interview

AP1-Project Proposal

Problem Statement

Organizational Memory is defined as the accumulated body of information created in an organization's history. The combined knowledge and experience of experts as well as physical records comprise the organizational memory of the aerospace industry. While physical records are readily preserved, capturing expert wisdom is far more difficult. As their careers draw to a close, many innovating aerospace professionals need an opportunity to share promising ideas that were never refined or published. The AIAA, as a subset of the aerospace community, could easily lose bright ideas through membership turnover. It is clear that the AIAA is in need of a method to organize and preserve such ideas for future use, since the lead-time for developing technology is generally lengthy.

Context

In the course of one's career, an aerospace professional will come up with a number of new ideas or concepts. Whether or not these ideas are expanded upon or developed is less certain. According to Professor Wilkes, based on a series of interviews he conducted, space scientists have noted that they can probably only plan, fund, build and assess the findings of one or two major missions in the span of their careers. These are typically complex group enterprises that shape an entire field, and the alternatives that were unable to attract enough interest to be pursued often get lost along the way.

An example is the Propulsive Fluid Accumulator (PROFAC) system, first proposed by Sterge Demetriates in 1959. Due to the sociopolitical atmosphere of the time, including international tensions and the firm belief within the industry that creation of a nuclear space drive was imminent, the idea was foregone and eventually classified due to concerns that the Russians would take it on. Now, fifty years later, there is growing interest in this rediscovered idea. Nuclear drives did not immediately supplant chemical rockets as expected and a way to cheaply refuel them is now of significant relevance.

In the post Apollo era, as the U.S. transitioned from a period of extensive aerospace R&D, less mainstream ideas suffered a loss of funding and support, which led to their dismissal. In addition, there is a general feeling within the upper echelon of the aerospace community that technically sound ideas would not have been overlooked for purely political or organizational reasons. This is a position with which our team disagrees.

Project Aims

The purpose of the Organizational Memory Project is to recover and revisit "lost" ideas of the retiring generation of aerospace engineers, and to gauge the magnitude of the field's organizational memory problem. We also hope to propose ways to mitigate the problem if it is as severe as we suspect it to be.

Our objective is to interview AIAA members and retirees about their ideas and experiences, then collect and organize our findings. The quantity of information gathered will serve as a measure of how prevalent the organizational memory problem is within the AIAA. Based on the results of the interviews, we will create a short presentation and share the most promising and original of our findings. If possible, a panel of AIAA New England members will be assembled to assess the likely

impact on the field had these ideas been pursued and proven to be as good as their advocates think they are.

Project Results

We expect the following results from this project:

- An understanding of the extent of the organizational memory problem in the AIAA NE community.
- To uncover ideas that would have otherwise been lost.
- An opportunity to reexamine proposals and ideas in light of new discoveries.
- To encourage communication and the fruitful synthesis of knowledge and ideas.
- To explore how to provide a link between those retiring from the field of aerospace and those, like ourselves, who are just entering it.

Implementation

The process required to successfully achieve the goals of this project can be broken down into a series of steps. Below is an outline of the major steps followed by a description of each requirement.

- Contact List Construction
- Idea Recovery
- Data Analysis
- Assessment Processing
- Final Report and Idea Presentation

Contact List Construction:

In order to collect data relevant to the general focus of the project in a timely manner, we believe it will be most effective to contact individuals at or near retirement age whose professional careers included research or development of upper atmospheric sciences, astronautics, and other related topics. During this stage we will determine candidates' willingness to participate in presentations on their topics. AIAA New England members will undoubtedly be a rich source of persons for this list. We also expect to network in other AIAA chapters, especially those near NASA bases and will try to recruit NASA sources as well. We are not looking for the most prominent and successful professionals. Instead, we are targeting those with some disappointment or who have been part of projects that were shut down.

Idea Recovery:

Idea recovery is the process of interviewing the set of all willing candidates. During this step, team members will conduct interviews in person or by phone. Members must select the most promising ideas using their best intuition.

Data Analysis:

After idea recovery, we will parse through the recovered information for any overlap or historical inaccuracies. If any are found we will conduct a follow up with the interviewee(s) to determine the circumstances of the inaccuracies and the correct results. All unverifiable materials will be omitted.

Assessment Processing:

Once we have completed data analysis, our team, in conjunction with industry experts, will determine which ideas are worth developing into a full-scale case study and be included in the final report. These will include what our group considers to be the most original and/or well-developed stirring ideas.

Final Report and Idea Presentation:

To conclude our project, members of the group will present the uncovered material. This presentation will include the best of our finds. We hope to each produce 3 full-scale (3-4 page) case studies and have about 5 more ideas developed at paragraph length. Our team consists of five people; therefore we should be able to pursue 15 promising leads and note around 25 more.

Budget

We expect to travel throughout the New England area to conduct interviews. If the AIAA New England can provide $500 funding, we can raise another $500 from WPI and with team member contributions we will have a $1250 budget. We anticipate that with AIAA funding we can accumulate a budget of approximately $1000 for travel and housing while on the road, while research/communication costs would be covered by the other $250 (these include telephone, postage, and paper costs). Depending on the results of our findings we may request further funding, at which time another formal request would be submitted. The most likely reason for needing additional funding would be if we are invited to travel to Florida, Texas, Alabama (Huntsville), California or Ohio (NASA center locations) to conduct interviews. This additional funding would likely be sought from the AIAA national office, or NASA itself, unless other local chapters can cover travel costs.

The more likely scenario is that AIAA Region I, including NASA Goddard in Maryland, would encourage us to expand this pilot project from New England to the entire northeast. Supplemental funding would be required to do this, however team members do have potential bases of operations with family members in Florida and Southern California, in which case, cost effective project expansion to these regions might be possible.

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508-831-5000, Fax: 508-831-6090
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Worcester Polytechnic Institute IRB #1
IRB 00007374

19 October 2010
File:10-154

Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609

Re: IRB Application for Exemption #10-154 "AIAA Organizational Memory"

Dear Prof. Wilkes,

The WPI Institutional Review Committee (IRB) has reviewed the materials submitted in regards to the above mentioned study and has determined that this research is exempt from further IRB review and supervision under 45 CFR 46.101(b)(2): "Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation."

This exemption covers any research and data collected under your protocol from 19 October 2010 to 18 October 2011, unless terminated sooner (in writing) by yourself or the WPI IRB. Amendments or changes to the research that might alter this specific exemption must be submitted to the WPI IRB for review and may require a full IRB application in order for the research to continue.

Please contact the undersigned if you have any questions about the terms of this exemption.

Thank you for your cooperation with the WPI IRB.

Sincerely,

Kent Rissmiller
WPI IRB Chair

AP3 Confidentiality Agreement

AIAA Organizational Memory Project Confidentiality and Informed Consent Agreement.

As volunteer staffer working with the AIAA on the Organizational Memory Project, I _____ agree to maintain the security and confidentiality of all information and data collected regarding the members of the AIAA, and other subjects of the OM Project. Maintaining the security and confidentiality includes but is not limited to the following provisions.

- All data and information collected either from interviewees or the AIAA will remain internal until release is approved by the individual or the AIAA, respectively.
- All data and information will be used for the sole purpose of conducting the research project. Data will not be used for any further purpose after the project is complete.
- Electronic files will be transferred in encrypted form only.
- Only one (1) copy of all physical data will be maintained. All other copies that may arise must be shredded.
- All personal data will be destroyed upon completion of the Organizational Memory Project, unless the AIAA decides to continue the project.
- The AIAA NE membership list will be used to identify a proposed group of people to be initially contacted by mail or Email and/or phone, but the actual letters will go out from the AIAA NE under authorized signature. There will be an accompanying full explanation of the project and its goals, how the information will be used and that the participant will have right of review. Phone contacts that are "initial" cannot be so closely supervised but it there will be a script based on the letter and it will be made clear that the contacting person is a volunteer staffer working for AIAA NE and that participation is purely voluntary and subject to right of review on whatever will become public information with or without the source being indicated, as they wish.

As regards Informed consent, any audio or video recording will include a first section that includes both identifying information and evidence that the participant has received a written explanation. They should state for the record that they consider the statement received sufficient, or they have had any questions answered to their satisfaction and are participating without misgivings or having been pressured by either an authority figure at work or a AIAA project staff member.

_____ _____

Signature Date

IQP Script

Sunday, October 31, 2010

2:13 PM

[Greeting] is (professional's name) available?

My name is (name). I'm a student working with the AIAA on a project to determine the extent of the Organizational Memory problem facing the aerospace community. Is this a good time to speak with you? I'm going to need about five minutes.

Basically, the team is trying to determine what happens to aerospace projects and ideas that are not pursued to completion, primarily in astronautics and space sciences. Our project involves interviewing individuals who have a relevant story to tell.

If you're interested in participating we have a few preliminary questions about the nature of your work. Before I ask you these questions I assure you all personal information will be available only by the authorized individuals of our team who've signed a confidentiality agreement with them AIAA. All information is handled with care.

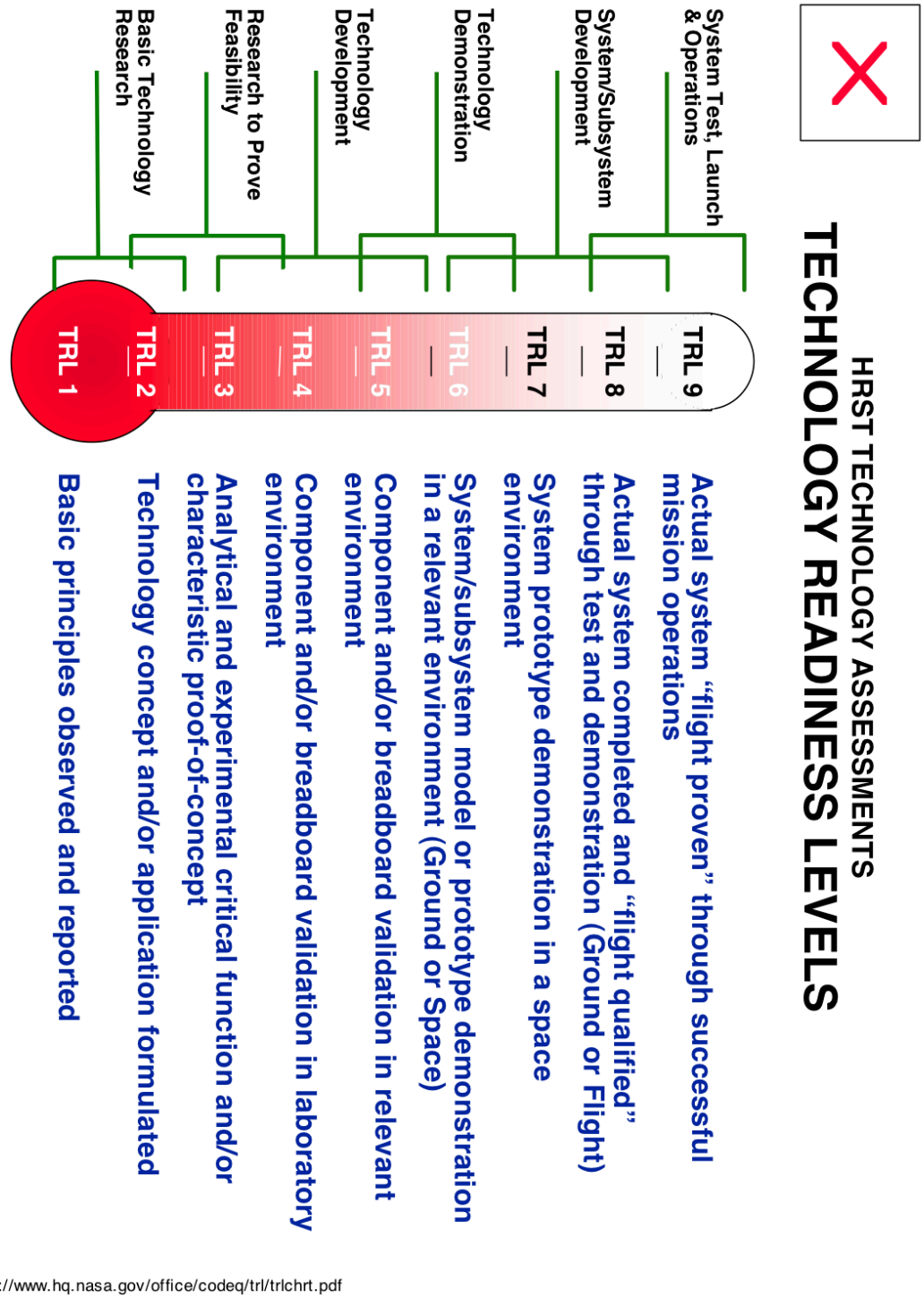
•What was your professional area of expertise?
•Where and when did you receive your education and in what areas of study?
•At this point in time, can you recall any projects that were never started or discontinued thatyou felt were promising? (Sentence talking about ideas.)

For our use:
•Do you know of anyone else who would be interested in participating in this project?
•If we are interested in interviewing you, may we contact you later to schedule a time and place?

If you think of anything else feel free to e-mail us at IQP-OM@wpi.edu

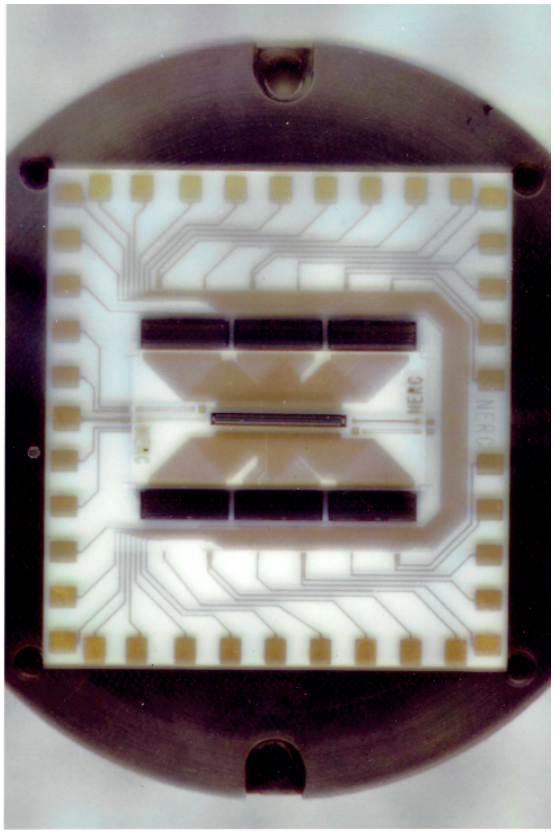
Thank you for your time.

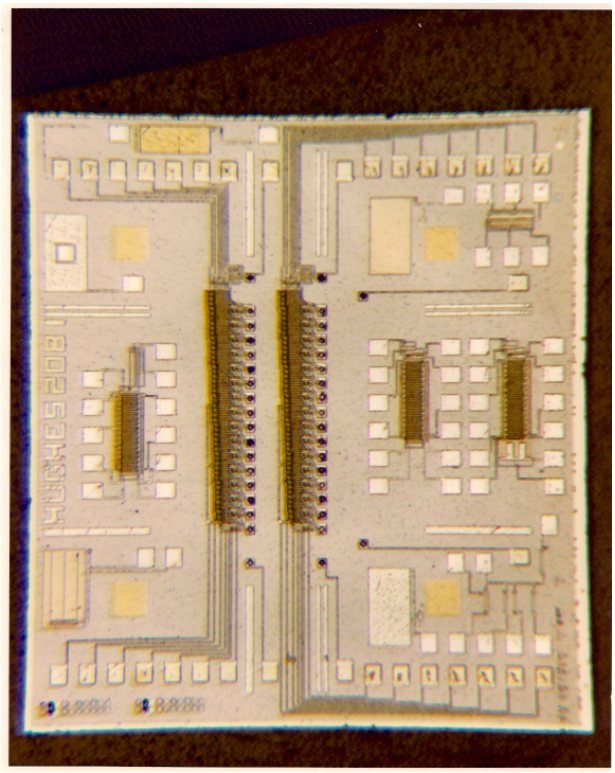
If no then (possibly later)

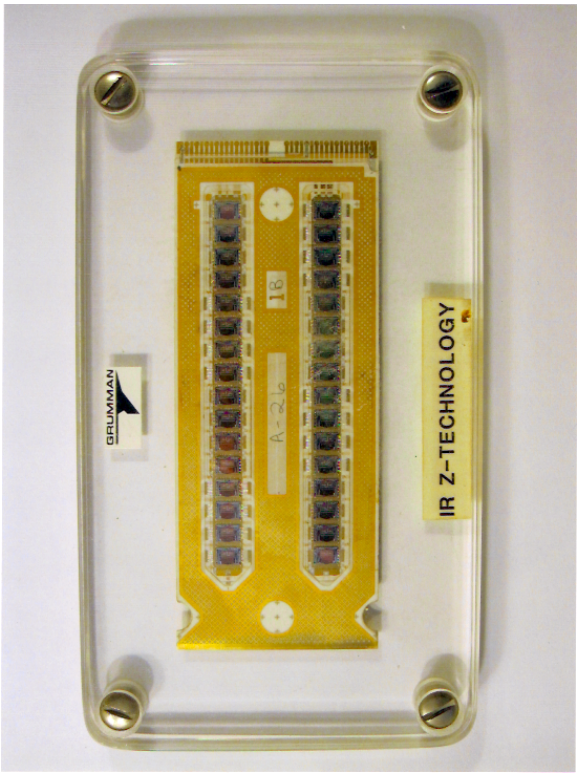


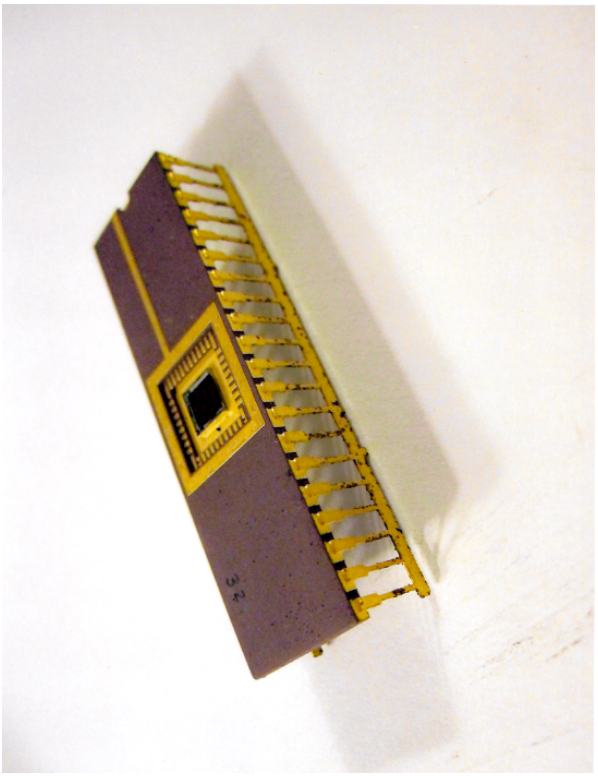
http://www.hq.nasa.gov/office/codeq/trl/trlchrt.pdf

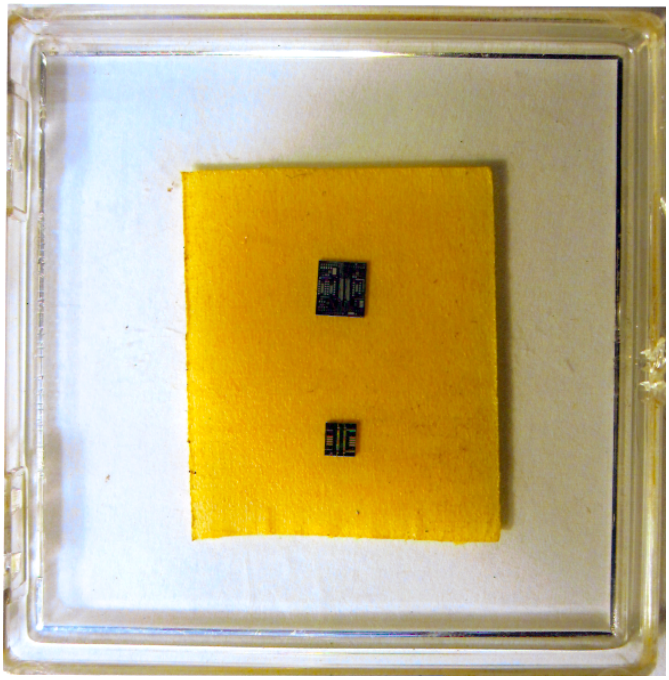
AP6 J. Fraser Photos

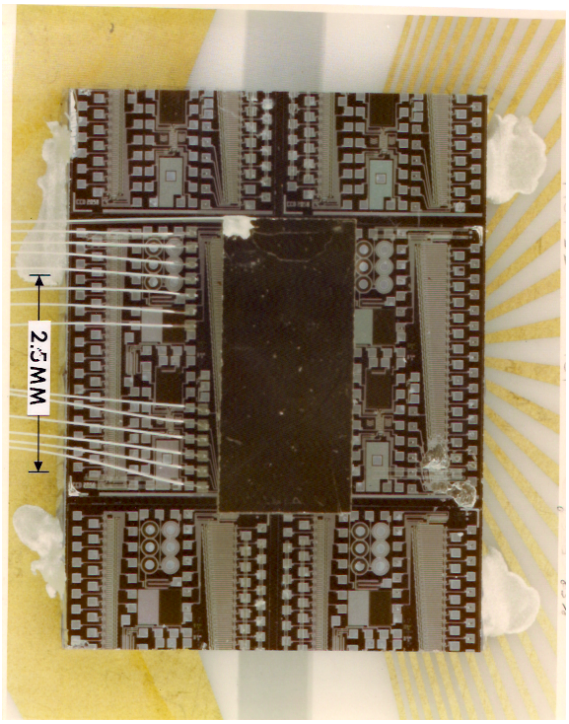








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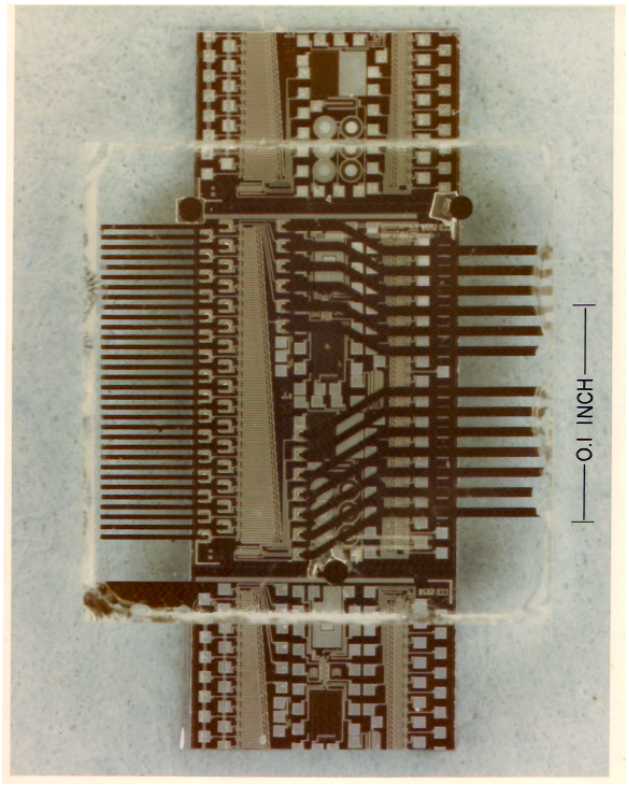
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AP7 J. Fraser References

Suggested Reading on Infrared Technology – Dr. James Fraser

Optical Radiation Detectors. Dereniak and Crowe

Infrared Detectors. A. Rogalski

Infrared Technology XV (Proceedings of Spie). Irving Spiro

Infrared Technology Fundamentals (Optical Science and Engineering). Spiro and Schlessinger

Optical Design Fundamentals for Infrared Systems. Max Riedl