GSDM Global Leader Program for Social Design and Management

AY2017 GSDM Student Initiative Project (SIP)

List of SIPs

Group ID	Project Title	Duration
17-01	Knowledge and Data Management for Policy Making Towards Data Driven Society	1year (Third year)
17-02	GLEG (Global Leaders X Ethics X Games) – Development of a new learning method for primary stages of ethical decision-making using gamification –	1year (Second year)
17-03	Space Innovation Policy for Disaster Management Capabilities (SIPDMC) - Extended	1year (Second year)
17-04	Disaster Management for the Future: Technological packages for Natural Disasters	0.5year (Second year)
17-05	Disease control for neglected infectious diseases	0.5year (Second year)
17-07	#UTokyo4SDGs	1year
17-08	Paradigm shift of cancer-cell therapy	1year
17-11	Food waste in Japan	0.5year
17-12	Self-Powered Sensor Device for the Elderly	0.5year

End of AY 2017 Report for SIP – Group 1

Project Title

ID: 17-01 Title: Knowledge and Data Management for Policy Making Towards Data Driven Society

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
16115	Kensaku Matsunami	Engineering	Chemical System Engineering	M2	Leader
16117	Cheng-Han Yeh	Engineering	Mechanical Engineering	D2	Leader
14126	Seonwoo KIM	Engineering	Mechanical Engineering	D2	Member
15120	Hiroshi Miyake	Frontier Science	Computational Biology and Medical Sciences	D1	Member
14108	Koki Muraoka	Engineering	Chemical System Engineering	D2	Member
13205	Anjar Dimara Sakti	Engineering	Civil Engineering	D3	Member
17109	Jie Zhu	Engineering	Chemical System Engineering	D1	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

In our modern society, the potential expectation of data-driven society to the extent that generating innovative businesses and creating values by both combining and exchanging data among different domains has been increased. By analyzing existing data with proper tools and good ideas, we can propose many good solutions to social problems. In AY2016, we performed a bibliometric analysis on academic papers to support decision making of the government on an evaluation of research of the different field. However, there is a significant gap between data, demands, ideas, and tools, which hinders proper unitization. Therefore, even we have solutions in hand, it is difficult to deliver our ide directly to demand. In this year's SIP, **we investigate the solution to fill the gaps between a solution to the demand**. The activity is mainly performed in two ways. The first is the analysis of public attention towards a certain event. Open data sources such as SNS data or search engine databases are analyzed to solve to sustain public attention on import events. The second is finding a proper way to deliver our solution to the organization on demand. We interview the target organization where we expect our solution can be used and study how the process of realization is processed.

Method: Explain through what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

In this SIP, we focused our scope on the data-assisted earthquake disaster prevention, which is increasingly demanded in Japan after the 311 earthquakes. The method was divided into two steps: (i) analysis of public attention data, and (ii) implementing the idea to the real world.

(i) Analysis of public attention data

We aimed to estimate the people's potential attention to earthquake, by developing a mathematical model on SNS data. We surveyed the online data resources which reflect the public consciousness to earthquakes. We selected Google Trends as the data we use, which provides the normalized index of the number of web searches about arbitrary keywords. Google Trends is superior regarding availability, and more importantly, the geographic information associated with each record. First, we trained each other by holding a lecture of data analysis using a programing language, R. We developed by ourselves a pipeline to recalculate a batch of Google Trends data from 2006 to 2017, and combined the data with the geological and seismological annotation of the earthquake, provided by Japan Meteorological Agency. We applied the Prophet model [1] to the time-series data to convert it to interpretable form, which consists of three factors; trend, periodicity,

and event-specific pulse. Next, we looked the persistence of the public attention deeply, by analyzing half-life time of people's attention to an earthquake after they experience it. To our surprise, people's attention to the earthquake is kept high only for one to five days, no matter how huge the disaster is. Furthermore, by analyzing the people in Tokyo, we observed the negative correlation between the half-life time of attention and the distance of epicenter. Those analyses let us observe the general tendency of the human attention to the earthquake, which is hidden behind the raw data.

(ii) Implementing the idea to the real world

We went to Tokyo Metropolitan Government (TMG) for the interview to learn how to implement the idea to the real world. The interviewee was Mr. Tooru Suda (Disaster Prevention Division, Bureau of General Affairs, Tokyo Metropolitan Government). The contents of interview were three topics: daily work routine/regular tasks, feedback of our project, and the work of disaster prevention utilizing the big data. Also, we tried to contact many academic professors: Prof. Hisashi Yoshikawa from UTokyo, Prof. Masaru Yarime from City University of Hong Kong, Dr. Kyoko Ohta from Ehime University, and Dr. Teruaki Hayashi from UTokyo to acquire the knowledge on how to apply the analysis on policy-making. We asked them what kind of stakeholders we should contact to, and how to implement outcomes of our project in the real world.

[1] Taylor, S. J., & Letham, B. (2017). Forecasting at scale. The American Statistician, (just-accepted).

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

As a result of the first step, some hidden messages, which are rarely noticed by the authorities, were revealed, e.g., the baseline of searching frequency rose after 311 earthquakes, short half-life time regardless of the event magnitude and regional dependence. The half-life time—the time required to decay to half of the peak top—was less than five days regardless of the magnitude of the earthquake. From more detail studies focusing on Tokyo citizens reacting to the event compared with nationwide, it can be concluded that people tend to pay attention to the events at close range.

Also in the second step, current situations of the government and knowledge were founded. From the interview with Disaster Prevention Division of TMG, we found that National Institute of Information and Communications Technology (NICT) is also developing tools utilizing SNS data, which also agree with one of our project directions. While this SIP project aims at analyzing the public awareness and promoting it in long-term using the history data, the system from NICT focuses more on real-time feedback for providing a more precise solution after the disaster occurs.

Other interviews, which are held with professors, indicated that it exists the difficulties of implementation of ideas into the real world, e.g., meeting higher authorities who is related to decision-making, and the importance of the human network. Without these key factors, the barrier to implementing our ideas into the real world would be much higher.

Overall, two steps were executed in this SIP project in AY2017. In step (i), the topic of earthquakes was selected and analyzed since there are wide varieties of data and it is highly related to the public. After some trends and new findings came out during the analysis, we proceeded to step (ii), which is to implement the ideas into the real world. For this purpose, we held several interviews with the authorities related to the earthquake prevention and public policies. The feedback from the interviewee was positive with some valuable comments which can be beneficial for the project in the following fiscal year.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense**
Traveling fee for the interview (Tokyo Metropolitan Government)	JPY3,732
Total	JPY3,732

End of AY 2017 Report for SIP – Group 2

Project ID & Title

SIP17-02 GLEG (Global Leaders X Ethics X Games) – Development of a new learning method for primary stages of ethical decision-making using gamification –

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ Member
15104	Haruku Shirahata	Engineering	Chemical system engineering	D1	Co-leader
15105	Kai Takeuchi	Engineering	Precision engineering	D1	Co-leader
15208	Akiyuki Masuda	Engineering	Systems Innovation	D3	Member
16102	Meng Su	Engineering	Precision engineering	M2	Member
17108	Guanxiong Wang	Frontier Sciences	Computational biology and medical sciences	M2	Member
17211	Asami Takahashi	Public policy		M1	Member
17201	Santosh Rauniyar	Medical		M1	Member
17205	Harushisa Yamamoto	Engineering	Systems Innovation	M2	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

The ethical capacity building including decision making is a large concern in the high school education. In Fy2016, we developed the interactive game to train the capacity to recognize broad perspectives which are needed to identify the potential ethical issues. The developed prototype games were implemented to GSDM students at the student-led session on March 18th, 2017. However, the educational effect of the prototype games are not declared with quantified analysis, and the target players of the games are limited to future global leaders. Therefore, to broaden the possibility of our game, we aim to implement the games at university or high school classes, which can lead to productization of the learning method including the games updated from the prototypes. For the goal, we set three objectives as follows;

1. Improve and confirm advantages of the game as an educational tool through implementations

To utilize our game as an educational tool, we needed to sophisticate the game to be endurable for the actual lectures in high schools. Since our game had been still prototype in FY2017, productized educational materials and a robust system were necessary to provide proper education. Additionally, the quantitative evaluation of educational effect is also needed to apply our game to high schools.

2. Contribute to educational effectiveness in HS classes about social issues by implementations

To address the issue of the ethics education in High schools, the implementation of our game in actual classroom is highly required. Only the implementation means truly giving a solution to a social problem.

3. Propagate our gamification approach and philosophy in educational society

Once our educational method is proven to be efficient for the issues of the ethics education, our method should be propagated to enhance the contribution for the society. In addition to the implementations at high schools, approach to the educational society would be advised to leave out method in schools.

Method: Explain through what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

1. Improve and confirm advantages of the game as an educational tool through implementations

To utilize the game as aneducational tool, we developed the new lecture style including the introduction, rules, facilitation and evaluation of the game which are suitable for the condition of high school classes. Additionally, the educational effect can be measured by the number of the ideas that students write down in the game. In the modification of the game, we have fabricated reusable materials which are made of a firm paper instead of nomal paper for the prototype as well as the online version game that enables convenient facilitation than that of the paper-based prototype. To achieve those achievments, we conducted several intervews with experts such as Prof. Kuri in Tohoku University, who is working on the project in which her team prooductized and commercialized an educational game, and Prof. Nishio in Tsuru

University, who provided us advice on the dilemma cases in our game.

2. Contribute to educational effectiveness in HS classes about social issues by implementations

As so far, we have done with four implementations (one at an university and 3 at high schools). Each implementation is conducted with positive feedbacks from the teachers. Our facilitation method is also improved so that the our lecture style got more feasible for high school cllases as we had the implementations. We also had a sinmplified workshop on our game in Musashi HS for next implementation in the next academic year.

3. Propagate our gamification approach and philosophy in educational society

To spread our method, we have presented the result of the implementation at Gakugei Univ. high school in the domestic conference 日本社会科教育学会. Furthermore, we had meetings with experts in education in Kyushu in March 2018 to get advises for propagation of our game. We also conducted the workshop in the Leading graduate program in Kyushu Univ. to share our idea.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

1. Improve and confirm advantages of the game as an educational tool through implementations

As the result of the quantitative evaluation of the implementation at Gakugei univ. high school, we demonstrated that our game enhances the capacity of students to imagine other perspectives which are proven by the increase in the number of students' ideas. In the light of the game facilitation, the reusable materials was also effective to reduce the effort to prepare the implementation which means the game have potential to be employed in high schools without our facilitation.

2. Contribute to educational effectiveness in HS classes about social issues by implementations

As we implemented our game, we found that High school teachers preferably employed out method in their classes. We even got an offer to implement the game in Musashi high school in following FY. It is indicated that our method is starting to contribute to the society by meeting the demands.

3. Propagate our gamification approach and philosophy in educational society

At the conference, our concept with the quantitative measurement of the educational effect was highly evaluated. It is suggested that our method has a potential to be employed in high school classes with a room for improvement.

With those outcomes, we addressed the issue of the ethics education in high schools by applying our educational method that has demonstrated the educational efficiency qualitatively and quantitatively.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense**
Books	3182
Implementation	32366
Travel fee	341160
Conference	7655
Supplies	49580
Online service	7128
Others	0
Total	441071

Appendix (option)

List of interviews

No.	date	Interviewee	Affiliation	place	purpose	contribution to the project	Interviewer	Budget spent (yen)
1	17 Sep, 2017	Prof. Osamu Nishio	Tsuru University	Sociology department, Tsuru University	Having feedback about our presentation at the domestic conference and implementations at high schools	Prof. Nishio is an expert in the social studies at high school, and he has the long-term experience of teaching at high schools. We had a discussion about effective dilemma cases to be used at high schools to attract the students to enjoy the game as well as to let them build the capacity of ethical decision making.	Meng Su, Guanxiong Wang, Akiyuki Masuda	5,460
2	20 Sep, 2017	Dr. Miwa Kuri	International Research Institute of Disaster Science, Tohoku University	Aobayama Campus, Tohoku University	Learning the strategy for productization by her experience with the “Disaster Mitigation Action Card Game”	Dr. Kuri is a faculty member of one of the Leading Graduate School “Inter-Graduate School Doctoral Degree Program on Science for Global Safety”. She is a mentor of a student group, and the group developed a card game for capacity building of disaster mitigation. They have an experience of commercialize their products, which is utilized to make our products propagated to the society.	Akiyuki Masuda, Kai Takeuchi	22,620
3	5 Mar, 2018	Mr. Yoshihiro Fuchigami	Kumamoto prefectural government, the Education bureau, Education instruction station, Senior High School Education Section	Kumamoto prefectural government	To have a discussion about dilemma seeds considering the current issues of high school students	Mr. Fuchigami was introduced by Prof. Yoshida, and he is working with improvement of high school educations. In particular, his group is working to prevent bullying among high school students, which is one of the biggest issues in recent high schools. We are going to find some dilemma seeds to be implemented at Musashi high school in March 2018, and in the next fiscal year.	Kai Takeuchi, Asami Takahashi	318,540 as the whole Kyshu trip)

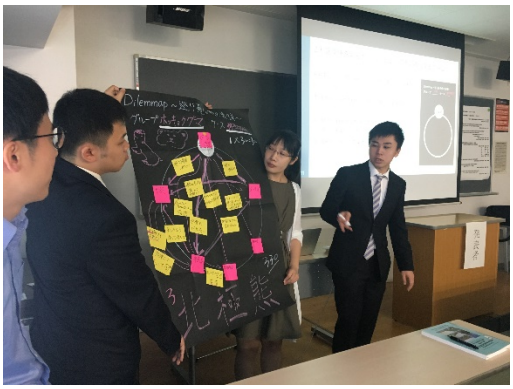
4	5 Mar, 2018	Prof. Michio Yoshida	Faculty of Education, Kumamoto University	Kumamoto University	To discuss the strategy to propagate our games to the society	We have once visited Prof. Yoshida in 2016, and have taken contact with him after the visit. He is an expert in education and has an experience of being a principal at a high school. We are going to have a feedback about educational outcome of our games, and the strategy of propagation.	Kai Takeuchi, Asami Takahashi	318,540 as the whole Kyshu trip)
5	6 Mar, 2018	Mr. MikiakiIwasaki	Foodbank Fukuoka	Headquarter of Foodbank Fukuoka	To learn their activities to reuse wasted food	Foodbank Fukuoka tries to reuse unconsumed food and distribute them to, e.g., children who cannot eat well at their home. The unconsumed food is offered by farmers, retailers, and consumers. We are going to hear their activities to reuse and distribute the unconsumed food to be shared at the implementation at Musashi high school.	Kai Takeuchi, Asami Takahashi	318,540 as the whole Kyshu trip)
6	6 Mar, 2018	Mr. Yasushi Matsuo	The Merry Corp.	Headquarter of Merry Corp.	To learn their activities to recycle wasted food	The Merry Corp. is a waste disposer of mainly wasted food. They have an original technology of decomposition of wasted food to utilize it as farmyard compost. We are going to hear their detail activities of utilizing wasted food to be shared at the implementation at Musashi high school.	Kai Takeuchi, Asami Takahashi	318,540 as the whole Kyshu trip)
7	6 Mar, 2018	Mr. Hironori Kikutake / Mr. Masakazu Yasumoto	Chief of the headquarters, The organization headquarters, FCO-OP / Chief director, Association activity department, FCO-OP	Headquarter of FCO-OP	To learn the countermeasures against food waste as a retailer	FCO-OP is a popular retailer in Fukuoka area, and implemented some countermeasures to reduce food waste by collaborating with food banks. We are going to hear their experiences or philosophy about the countermeasures to be shared at the implementation at Musashi high school.	Haruku Shirahata, Santosh Rauniyar, Meng SU	318,540 as the whole Kyshu trip)

Implementation list

No.	date	Teacher in charge	Affiliation	place	Implemented dilemma cases	Contribution to the project	Visited member	Budget spent (yen)
1	17 Jun, 2017	Mr. Shuntaro Yamakita	Tokyo Gakugei University Senior High School	Setagaya-ku, Tokyo	1. Planning the venue of the high school trip 2. Allowing a maternity leave for high school students	Confirmed the educational effectiveness of our games both quantitatively and qualitatively.	Kai Takeuchi, Haruku Shirahata, Meng Su, Guanxiong Wang, Akiyuki Masuda	7,560
2	30 Nov, 2017	Mr. Hirotaka Hanai	Izumi High School	Saitama-city, Saitama	Reducing food wastes	Experienced to provide a dilemma case from the interests at the high school. Confirmed that our game can be implemented in the environment with no internet access.	Haruku Shirahata, Meng Su, Haruhisa Yamamoto	6,106
3	12 Jan, 2018	Mr. Hiroyuki Toyooka	Yashio-minami high school	Yashi-city, Saitama	Implementation of bike lanes in Yashio-city	Experienced to provide a dilemma case from the concern at the high school. Confirmed that the former part of our game can also be facilitated by teachers at high schools, not by the project members	Haruku Shirahata, Santosh Rauniyar, Haruhisa Yamamoto, Akiyuki Masuda	7,040
4	19 Jan, 2018	Mr. Kiyoshi Karaki	Master's program in education in University of Tsukuba	Tsukuba-city, Ibaraki	1. Planning the venue of a high school trip 2. Reducing food wastes	Had some feedback from students with the experience of teaching at high schools about the educational effect of our games. Propagated our game to the students who will be high school teachers in the future.	Haruku Shirahata, Asami Takahashi	6,760

5	7 Mar, 2018	Prof. Kun Qian	Graduate education and research training program in Decision Science for a sustainable society, Kyushu University	Fukuoka -city, Fukuoka	1. The dilemma case provided by the program in Kyushu Univeristy 2. Reducing food wastes	The program in the Kyushu University Workshop with a Leading Graduate Schools “Decision Science” focuses on making decisions to be successful under uncertainties with various stakeholders. Our game focuses on letting students realize dilemmas, which is the former stage than the one the program focuses on. We are going to have a workshop with them to propagate our game, and to find a possibility to make a collaboration with them.	Haruku Shirahata, Akiyuki Masuda, Kai Takeuchi, Asami Takahashi, Meng Su, Santosh Rauniyar	318,540 as the whole Kyshu trip)
6	13 Mar, 2018	Mr. Hiromasa Kajitori	Musashi high school	Nerima-ku, Tokyo	1. Reducing food wastes 2. To be decided by considering the school’s concerns or interests	We already had a discussion with Mr. Kajitori, the principal of the high school, to discuss about the dilemma seeds of the high school. The school has the characteristic as all-boy schools, and has the unique activities to let the students learn from the actual society. The dilemma cases to be used are going to be decided based on the experience at the interview at Kyushu.	Haruku Shirahata, Akiyuki Masuda, Kai Takeuchi, Asami Takahashi (for the dicusussions)	4,940

Pictures at the domestic conference on Sep. 17th, 2017 (The 67th Japanese Association for the Social Studies annual conference)



Details of budget implementation

Purposes	**Detail**	**Expense**
Books	オムニバス技術者倫理研究会, “オムニバス技術者倫理 第 2 版”	3182
Implementation	Tokyo Gakugei University Senior High School (Tokyo, 4 students)	7560
	Izumi High School (Saitama, 3 students)	6106
	Yashio Minami High School (Saitama, 4 students)	7040
	Master’s program in education in University of Tsukuba (Ibaraki, 2 students)	6760
	Musashi High School) (Tokyo, 10 students in total)	4940
	Total	32366
Travel fee	Interview with Dr. Kuri (Tohoku Univ.)	22620
	Interview with Prof. Yoshida (Kumamoto Univ.)	318540
	Interview with Mr. Fuchigami (Education Agency of Kumamoto Prefecture)	
	Interview with FCO-OP (Fukuoka)	
	Interview with The Merry Corp. (Fukuoka)	
	Interview with FOODBANK FUKUOKA (Fukuoka)	
	Workshop with Graduate Education and Research Training Program in Decision Science for a Sustainable Society (Kyushu Univ.)	
	Total	341160
Conference	Oral presentation in The 67th Japanese Educational Research Association for the Social Studies (JERASS) Annual Conference	7655
Supplies	Blackboard sheets, marker pens	49580
Online service	Web server	7128
Total		441071

倫理的意思決定のための能力育成ゲーム開発

―東京学芸大学附属高等学校における授業実践―

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華井和代（東京大学）

【キーワード】倫理教育、ゲーミフィケーション、可視化

１．はじめに

多くの現実的な意思決定において、多様なステークホルダー（以下、関係者）が存在し、トレードオフ関係が存在する。このような状況における倫理的な意思決定は容易ではない。

高校公民科の学習指導要領では、「倫理」の目標として、「他者と共に生きる主体としての自己の確立を促し，良識ある公民として必要な能力と態度を育てる」ことが掲げられている。この目標の達成には、社会の潜在的な問題や未経験の事例に対して柔軟に対応する想像力を身に着けることが重要になる。本報告では、こうした柔軟な発想を促す手段としてゲーミフィケーションの有効性を示す。近年、ゲーミフィケーションが教育で用いられる事例は増えてきており、能力向上に有効なアプローチとして認識されている[1]。そこで報告者は、倫理的意思決定に資する能力を育成する教材として、高校倫理の授業に適したゲームを設計し、開発した。既往の研究によると、倫理的意思決定のプロセスは、潜在的なジレンマなどの問題認識と意思決定に分けて考えることができる[2]。本ゲームは問題認識の段階に焦点を絞り、広い視野のもとで多様な人々の観点を想像すること、利害関係を可視化することを通した問題構造を理解することに特化した能力向上を意図している。報告者は高校生を対象に授業実践を行い、その内容と教材としてのゲームの効果を報告する。

２．開発したゲームの内容

「Ethics against Ethics（以下、EaE）」、「Dilemmap」と名付けた 2 段階構成のゲームを開発した。両ゲームでは、プレーヤーに対して、予め用意した仮想の社会問題の事例(以下、事例)を提示する。この事例ではある特定の当事者の視点での解決案が一つ提示されている。前者のゲームは 3-4 人で構成されるテーブル内で行われ、仮想事例内で提案が実行された結果について、関係者に及ぼしうる負の影響(観点)についての発想力を競わせる。プレーヤーに着想した観点をオンライン上に投稿してテーブル内で共有させ、質の高い観点に対して相互投票によって得点を決めさせた。その際、事前に前提条件、関係者、内容について発想するよう指示し回答形式を統一した。また観点の相互評価の軸を「なるほど」「あり得そう」「ユーモア」とすることで柔軟な発想を促した。Dilemmap では、各テーブル内で EaE で挙げた観点をもとに、関係者間の利害関係を矢印で図式化させた(図 1)。他の関係者を介して提案者自身に向かう利害関係のループをジレンマとして定義し、認識したジレンマの数とその論理性を競わせた。図式化したジレンマの構造をテーブルごとに発表させ、最も論理的な Dilemmap を相互投票によって評価させる。また、Dilemmap では一つの仮想事例について模造紙上に直接利害関係図を書かせることで、プレーヤーやテーブル間での共有を容易にした。ゲームの設計では色合いなどの審美的側面についても考慮した。

図１　授業風景（Dilemmap の発表）

３．分析方法

ゲームの教育効果は参加者のゲーム中の回答についての統計と事後アンケート調査の結果の二つのアプローチで評価した。EaE では合計 4 回のプレーを行い、1〜3 回目では難易度別の異なる仮想事例を用いた。Dilemmap では全テーブルを二分割し、各グループは EaE の事例のうち別の事例を扱った。

４．授業報告

授業実践は 2017 年 6 月に東京学芸大学附属高等学校の選択科目「探究授業」において、2 年生 22 名（男 19、女 3）を対象として行った。

EaE で投稿された観点の総数をプレー回ごとに測定したところ、3 回目までは漸増し、4 回目では一度用いた事例を再提示しているため、観点数は伸びなかった。また図 2 に示されるように、回数が進むにつれピーク到達までの時間が早くなることがわかる。効果測定のための 4 回目のプレーは 3 回目終了から 90 分後に行われたが、着想の早さは維持されており、発想の能力が定着しつつあることが示唆される。ゲームの手続きへの慣れや、事例の差を除いた正味の効果の評価にはさらなる分析手法の検討が必要であるものの、生徒が EaE を通じて、多様な人々の観点を想像することを学習したことが定量的に示された。

また、授業を通して生徒が躊躇せずに自身の意見を発表する姿が見られ、電子デバイスを用いた匿名での回答方式が効果的であった。アンケートでも、「気軽に意見をだすことができた」「たくさんのアイデアを使って共有できた」といった意見が見られた。

Dilemmap では 6 テーブル中、最大 5 つの関係者が関わるジレンマが見出されており、潜在的なジレンマでの複雑な利害関係が体系的に図式された。また、事例の難易度によるジレンマの数については大きな差は見られず、ゲーム構造自体によって、個々の着想を継ぎ合わせ、潜在的なジレンマを認識するに至ったと言える。アンケートにおいても、複数の事象の利害関係を図式化することによって学ぶことができたという感想が見られた。

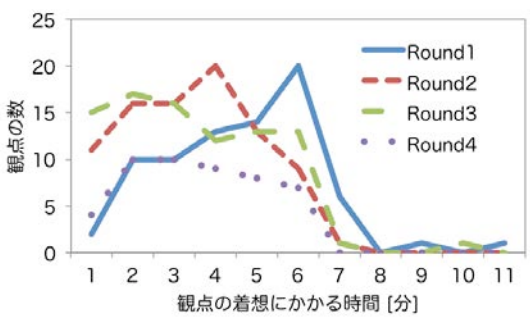

図 2　観点の投稿数推移

ゲーム全体についてのアンケートでは本授業を通じて視野が広がったかという問いに対して、16 名が広がった、4 名が変わらない、2 名がわからないと回答した。このゲームが視野を広げるという意味で、倫理的素養の育成に一定の効果を持つと考えられる。

またこのゲームの効果が単に利害関係を可視化することに留まるという指摘もあった。倫理という言葉が強調されすぎるとかえって発言が慎重になり集合知のメリットが活かされない。このゲームでは倫理は一般的な意思決定の側面であると考え、特段の思考方法のフレーミングは行わなかった。

５．まとめ

本ゲームは潜在的なジレンマなどの問題認識力に焦点を絞っている。高校生を対象とした授業実践分析ではプレーヤーは仮想事例における発想力と、それに基づくジレンマの認識に必要な能力を育成した。電子媒体による回答や、ユーモアを回答の相互評価軸に加えることによって、プレーヤーの積極的な参加を可能とした。生徒のゲーム中の回答についての統計と事後アンケート調査の結果の二つの評価アプローチで、目的とした能力の向上が見られ、潜在的な問題や未経験の事例に対して柔軟に対応できる想像力を身に着ける教材として一定の効果をあげた。

謝辞

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脚注

[1] Davis, M. (1999). Ethics and the university. New York: Routledge.

[2] Kapp, K. M. (2012). The Gamification of Learning and Instruction. San Francisco: Pfeiffer.

End of AY 2017 Report for SIP - Group 3

Project Title

Space Innovation Policy for Disaster Risk Management

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
16080	Giulio Coral	Engineering	Aeronautics & Astronautics	D1	Leader
16206	Hiya Roy	Engineering	Electrical Engineering & Information Systems	D1	Leader
16201	Quentin Verspieren	Public Policy	International Public Policy	D1	Leader
16114	Marc-Andre Chavy-Macdonald	Engineering	Systems Innovation	D3	Member
15202	Budhaditya Pyne	Engineering	Electrical Engineering & Information Systems	D3	Member
16111	Goutham Karthikeyan	Engineering	Aeronautics & Astronautics	D3	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

The overall objective of the project "Space Innovation Policy for Disaster Risk Management" is to study space development, in the Asia-Pacific region mostly, from a Science, Technology and Innovation Policy perspective, for applications focussing primarily on disaster management and environment monitoring.

Our main target is two-fold: (1) a macro-level study on innovation policy in the space sector in general, quite theoretical, that we call "Innovation Panorama" and (2) a micro-level evaluation of a specific interesting case, the Philippines National Space Development Program, for which we produced several outputs.

Overall, the objective of this project is thus to improve the natural disaster mitigation in Asia, with a special focus to the relatively more disaster prone and economically weaker Southeast Asia. The background is that Southeast Asia is one of the most natural disaster-prone regions of the world, and lacks the sociopolitical, economic and technological systems to mitigate them. A 2015 UNESCAP report estimated that 6 billion people from the Asia-Pacific region were affected by natural disasters from 1970-2014, or 88% of people affected globally during that period. Natural disaster mitigation requires significant infrastructure investments and hence financial resources, but space systems can fill this gap by providing leapfrog "instant infrastructure", with lucrative cost savings via international cooperation. The space sector has seen a marked increase in innovation in the past few years, and it is now possible to capitalize on rapidly expanding possibilities for technology development and novel systems deployment.

Method: Explain through what kind of approaches you tried to achieve the objective.
*About the list and details of the interview, add the appendix.

This project will use plural social science research method to portrait possible effective policy changes to government in satellite innovation and procurement processes.

Work on innovation policy will be subdivided in two main blocks: (1) Investigation on the space innovation landscape, focusing on actors and institutions involved, and (2) Data analytics, focusing on defining appropriate methods to analyze these characteristics. Combining these two aspects we will be able to produce a tentative analysis of the innovation panorama regarding space technology, useful for applications ranging from policy recommendations to business analytics.

The case study on the Filipino space program was based on the unique opportunity to witness the inception of a national space program. The main source of information was a research trip to the Philippines, in which we could visit the Department of Science and Technology (DOST), the National Space Development Program (NSDP), the PHL-Microsat group, the University of Philippines Diliman.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

- A poster presented at the UN-SPIDER conference in Beijing (Sep. 2016): *Space Innovation Policy for Disaster Management Capabilities*
- Two presentations at the GPPN in Sciences Po, Paris (Feb. 2017): *Shelter 2.0* (also presented as a social startup idea at Hult Prize Dubai, Mar. 2017) and *LESAT (Location-based Emergency Shelter Awareness and Training)*
- Two presentations at the 68th International Astronautical Congress: *Space Innovation Policy for Disaster Management Capabilities: A Case Study on the Nascent Filipino Space Program* and *LESAT*
- Upgraded the paper "Space Innovation Policy for Disaster Management Capabilities: A Case Study on the Nascent Filipino Space Program" into a journal paper "An Early History of the Philippines Space Development Program," submitted on February 27, 2018 to *Acta Astronautica* (Elsevier)
- Two members (Goutham and Marc) created a startup company *Optimacy*

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense**
UN Conference in Beijing, September 2016	155,000 JPY
IAC 2017, September 2017	297,060 JPY
Research books	23,000 JPY
Fieldwork in Manila, January 2018	285,000 JPY
Total	760,060 JPY

68th International Astronautical Congress (IAC), Adelaide, Australia, 25-29 September 2017.

28th IAA SYMPOSIUM ON SPACE AND SOCIETY (E5)
Space Assets and Disaster Management (4)

IAC-17-E5.4.8

SPACE INNOVATION POLICY FOR DISASTER MANAGEMENT CAPABILITIES: A CASE STUDY ON THE NASCENT FILIPINO SPACE PROGRAM

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Abstract

In its 2015 Asia-Pacific Disaster Report, the United Nations Economic and Social Commission for Asia-Pacific (UNESCAP) noted that between 2005 and 2014, 1,625 disasters had been reported, killing half-a-million people, affecting the life of approximately 1.4 billion and generating economic damages worth US $523 billion. In particular, the Filipino archipelago concentrates several risk factors for hydro-meteorological disasters. Although most of these deadly disasters can be addressed using a wide range of space technologies (space remote sensing, satellite communication and positioning systems), the access to such technologies is highly unequal. For this reason,the Philippines initiated in 2015 the National Space Development Program (NSDP), aiming at the establishment of a national space agency and an indigenous satellite industry within the next two decades. Starting from a presentation of the origins and motivations of the Filipino space program, this paper explains in detail the current progress of its development as well as addresses more generally the space policy goals of the Philippines. Finally, this paper introduces initial considerations, from an innovation studies perspective, on the Filipino space development program, as a very interesting case study for a larger reflection on space development in the Asia-Pacific region.

Keywords: Philippines Space Development Program, Innovation Policy, Disaster Management, NSDP

Introduction

As the most disaster-prone region in the world, Asia-Pacific suffers from close to 40% of the globe's 'natural' catastrophes [9]. Since 1970, more than 5000 major disasters have hit this region causing more than 2 billion fatalities and affecting the lives of around 6 billion [30]. The Philippines, in particular, being a low-lying coastal country, is continuously at high risk. As promoted in the *Sendai Framework for Disaster Risk Reduction 2015-2030*, the use of Earth Observation (EO) should be increasingly used for the evaluation of hazard exposure, vulnerability and risk and is therefore an indispensable source of information to support decision-making related to disasters [31].The Philippines do not have a national space agency and hence must rely on cooperation from international space agencies of developed countries like NASA and JAXA. The Philippine institutional arrangements and disaster management systems tend to rely on a reactive approach, in contrast to a more effective proactive approach, in which disasters are avoided, by appropriate land-use planning, construction and other pre-event measures which avoid the creation of disaster-prone conditions [7]. To evolve to a more proactive role, it is important that a national framework for comprehensive disaster risk management be prepared and implemented which incorporates the essential steps of integrated risk management, including risk identifi-

cation, risk reduction, and risk sharing with financing. Establishing a dedicated space program and a National Space Agency can go a long way in serving these needs. Following this reasoning, Filipino House Representative Angelo B. Palmones proposed in December 2012 the establishment of a Philippine Space Agency (PSA) in a bill which however failed to pass.

1 The first steps of space development in the Philippines

The original vision of the 2012 bill was to establish a self-reliant and coherent space program supposed to play a pivotal role for the national economic and social development for the Philippines [7]. With the belief that space science should not be the monopoly of developed countries, the scientific vision of the PSA was inspired from the *Twelve-year Plan for Chinese Aerospace* and the Space Research and Remote Sensing Organization (SPARSSO) of Bangladesh, which works closely with JAXA, NASA and ESA. One the other hand, the proposed business model took inspiration from the Chinese Great Wall Industry Cooperation (CGWIC), created for the design, manufacturing and launching of satellites. The focus was on general space science exploration and improving telecommunication standards to upgrade and replace Agila-2, the only Filipino-owned satellite which was designed and built by CNES and decommissioned in 2013. However, it failed to resonate with the major needs of the Filipino people or gain much public or political support since these goals were by no means a high priority of a developing country like the Philippines, frequently stricken with poverty and catastrophic natural disasters. Coincidentally, Palmones also faced subsequent electoral trouble which further impeded the chances of the bill to succeed.

Super-Typhoon Haiyan (also known as Yolanda), which made landfall in the Philippines in November 2013 — killing 6300 victims, affecting over 16 million people and causing economic damages greater than US $800 million in the Philippines alone [29], proved to be a turning point for the Philippines space program. The Filipino authorities were prepared for record-breaking wind-speeds, but totally unprepared to deal with storm surge despite early warnings. Hence the citizens in the affected regions were not evacuated leading to catastrophic consequences and Haiyan became the costliest and deadliest typhoon to have ever hit the Philippines in the last century. After Haiyan, an opinion poll among Filipino citizens suggested that they considered Disaster Preparedness to be their greatest concern, surpassing poverty [10]. Subsequently, Dr. Rogel Sese, a well-known Filipino astrophysicist[1], carried out a survey of the needs of national stakeholders of a potential Filipino space program, and came up with a proposed structure for development of space science in the Philippines [25]. This led to a change in political will in the Filipino Government and eventually to the foundation of the NSDP in September 2015 followed by the PHL-Microsat Program in early 2016 through the initiative of the Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD) of DOST. They will serve as interim development programs to prepare for the creation of the PSA by studying its feasibility and usefulness.

2 The two aspects of space development in the Philippines

As preliminary stages for the development of the PSA, the DOST has been separately supporting two programs with different goals: the National SPACE (*Space Promotion, Awareness, and Capabilities Enhancement*) Development Program (NSDP) focusing on the political side, and the PHL-Microsat program working on the technical side.

2.1 Political Side: The National SPACE Development Program

In 2014, two years after the failure to establish the PSA with House Bill 6725 [7], Dr. Rogel M. Sese started investigating the concept of space development by heading a project with the DOST on the crafting of a *Philippine Space Development and Utilization Policy* (NSDUP). From a survey of all potential stakeholders of a Filipino space development program, six Key Development Areas (KDAs) were identified, leading to the official establishment of the NSDP in September 2015 by the DOST [34].

The NSDP is responsible for a large number of tasks, indispensable to initiate a domestic space agency as well as indigenous satellite development capabilities [13]:

- Prepare several documents such as a **National Space Research and Development Agenda** to define a timeline for the implementation of the *National Space Development and Utilization Policy*, a **Satellite Development Roadmap** to define the

[1] Currently Focal Person for the Philippine Space Science Education Program (PSSEP) of the Department of Science and Technology's Science Education Institute (DOST-SEI) and Program Leader of the NSDP.

specific satellite technologies needed by the Philippines in the next 15 years, a **Space Industry Development Roadmap**, a **National Satellite Data Sharing and Management Protocol** to simplify procedures for satellite data handling and sharing and a **Philippine Satellite Data Catalog** to compile all available data in the Philippines.

- Study opportunities of collaboration with international organisations for all space-related activities.
- Promote the participation in regional and international forums for space technology development and utilisation.
- Define the institutional arrangements under which the PHL-Microsat project and the Philippine Earth Data Resource and Observation (PEDRO) will be integrated into the PSA in the future.
- Define the various roles of domestic stakeholders in their relations to the PSA.

As a mainly policy-focused entity, it is clear that the main goal of NSDP is to define the characteristics and lay the groundwork for the creation of the PSA by analysing the various needs of the stakeholders and addressing their respective concerns. While the outputs of the NSDP are confidential — due to strict regulations of the DOST — the spirit of these documents, and in particular the *National Space Development and Utilization Policy*, can be found in the variety of bills proposed in the House and Senate (see 4.2).

2.2 Technical side: PHL-Microsat

PHL-Microsat followed a similar timeline as the NSDP, with a concept definition in 2013-2014 and implementation from 2015. While also initiated and financially supported by the DOST, it has no direct relationship with NSDP, as it pursues different goals [35]. NSDP is however closely following the progress of PHL-Microsat, as it is an indispensable milestone towards the establishment of the PSA [34].

With Philippine universities and other research centres currently lacking necessary know-how required to build a satellite, as pointed out by Dr. Sese, PHL-Microsat entered into a partnership with Tohoku University (for the bus development) and Hokkaido University (for payload and thermal design) in Japan [17]. It allowed PHL-Microsat to produce Diwata-1, the first satellite built and developed by Filipino engineers. Diwata-1 was launched on March 23, 2016 from the International Space Station using JAXA's Kibo module. It is currently on a circular Low Earth Orbit of 51° of inclination and an altitude of 400 km [16].

Concerning more technical characteristics, Diwata-1 is a 50-kg micro-satellite with three main instruments [17]:

- A high precision telescope with a spatial resolution of 3 meters at 400 km altitude for disaster damage evaluation.
- A multi-spectral imager with liquid crystal tunable filter, having a spatial resolution of 80 meters, for ocean monitoring.
- A wide field camera with a seven-kilometre spatial resolution for meteorological forecasting.

Diwata-2 is scheduled to follow in 2018, with improved instrumentation and capabilities [18].

While it is unclear whether PHL-Microsat will be integrated into the PSA or support some commercial spin-offs, the goal of training local engineers and scientists has clearly been fulfilled. As an example of the impact achieved, for the first time the University of the Philippines Diliman is teaching a space-related course "Introduction to Space Technology" [35].

3 Domestic support

Nationwide acceptance is essential for the adoption of such a costly initiative as space development. In particular for developing countries stricken with poverty like the Philippines, establishing a program costing hundreds of millions of US$ requires substantial domestic support from all levels of society.

3.1 Public opinion

The most important target for the promotion of the Philippines' space program is the Filipino people. An efficient governmental promotion strategy as well as the success of Diwata-1 greatly contributed to establish the current strong public support towards space technology development in the Philippines [34].

3.1.1 Efficient governmental promotion strategy

While the 2012 PSA bill failed to pass in the House possibly due to an overwhelming focus on space science and telecommunication, the government of the Philippines and in particular the DOST adopted a new approach for the promotion of space development, based on the real concerns of the Filipino people. This new communication strategy relies on three axes: disaster

management, agriculture and the environment. These elements resonated in the minds of Filipinos, and became a game changer compared to 2012.

The second aspect of the governmental strategy for the promotion of space technology consists in outreach events organized by the DOST. In particular, the annual National Science and Technology Week, organized last time in July 2017, has had a great positive impact over the Filipino youth, by showcasing the first successes of the Philippines' space development program such as Diwata-1.

3.1.2 The great effect of DIWATA-1

The most recent milestone of the Philippines' space program is the launch of Diwata-1, the first satellite ever developed and built by Filipino citizens, and thus first Filipino micro-satellite.

From the beginning, the role of Diwata-1 was to accelerate the process of establishment of the PSA, as declared last year by Dr. Joel Joseph S. Marciano, project leader of PHL-Microsat in the *Manila Bulletin* [32]. Therefore, the success of Diwata-1 strongly resonated in Filipino society thanks to large media coverage, associated with strong comments from the state. In fact, following the deployment of the satellite from the ISS's Kibo module, the House of Representative of the Republic of the Philippines issued a resolution to express the "jubilation" felt by the Filipino people as well as the positive impact of Diwata-1 in "heightening the call for a larger government support for science and technology" [8]. The DOST also unsurprisingly welcomed the launch of Diwata-1 with utmost consideration, as initiator of the project.

However, while Diwata-1's launch was widely celebrated in the Philippines, the lack of any comment from President H.E. Rodrigo Duterte should be noted.

3.2 Political support

From the political side, the establishment of a Filipino Space Agency has also been associated with a tremendous support in both chambers of the Congress. In fact, no less than six bills aiming at the creation of the PSA are currently being examined in the House and the Senate.

3.2.1 In the House of Representatives

Four bills were submitted in the House of Representatives under the name of "Philippine Space Act of 2016" or "PhilSA". The first house bill was proposed by Rep. Erico Aristotle C. Aumentado and Rep. Seth Frederick P. Jalosjos on September 15, 2016 [3], followed by Rep. John Marvin "Yul Servo" C. Nieto and Rep. Edward Vera Perez Maceda on November 7, 2016 [4], Rep. Joey Sarte Salceda [5], and Rep. Maximo B. Rodriguez, Jr. on December 6, 2016 [6].

An interesting point is that all bills are exactly the same. It has however been welcomed warmly by the NSDP, as it displays a clear interest of the House for the PhilSA and helped to accelerate the adoption process [34].

It was recently decided to merge all four bills into a single one, which is currently being drafted [36].

3.2.2 In the Senate

The senate has seen two proposed bills, under the name "Philippine Space Act", the first one by Senator Paolo Benigno "Bam" A. Aquino IV on October 18, 2016 [20] and the second one by Senator Loren Legarda on December 1, 2016 [21]. Their text is exactly similar as the House bills.

Concerning the status of the bills, they have already been discussed in the first Technical Working Group Meeting in the Senate [36], and are still in the process of becoming laws.

4 Space Policy of the Philippines

Having seen the high level of domestic support for the Philippine space development program, and therefore the likeliness of the *Space Act* being adopted by the Congress, it is interesting to further investigate Filipino space policy.

4.1 Proposed bills in House and Senate

The most interesting available sources to learn elements of space development in the Philippines are the various bills proposed in the House of Representatives and the Senate. While documents produced by the NSDP are confidential, it has been brought to the authors' attention that the bills contains most of the spirit of these documents, and in particular of the *Philippine Space Development and Utilization Policy* of 2014 [36].

As explained in 3.2, all bills have the same text. Divided into 24 sections, the bill defines all elements related to space development in the Philippines. While the scope and goals of the Philippine national space policy will be presented in 4.2 and the roles and structure of the PSA in 4.5, this section will focus on the other elements included in [3].

In particular, section 19 proposes the creation of a *Philippine Space Development Fund* of 10 billion pe-

sos (approx. US $196.4 million[2]) granted by the Filipino government from its share in the gross income of the *Philippine Amusement and Gaming Corporation* and the *Bases Conversion and Development Authority*. From this budget, 2 billion pesos (approx. US $39.3 million) will be transferred to the PSA every year for five years. This fund will also be authorized to receive grants, donations and contract loans with financial institutions.

4.2 *The Philippine Space Development and Utilization Policy*

The most important document summarizing the space policy of the Philippines is the *Philippine Space Development and Utilization Policy*. According to [3], the Filipino space policy will focus on six "Key Development Areas":

1. "National Security and Development" to ensure the development of space applications increasing the security of the Filipino people.

2. "Hazard Management and Climate Studies": as explained previously, disaster management is one of the biggest priorities of the Philippines as well as the main reason to initiate a space development program after the deadly Haiyan typhoon.

3. "Space Research and Development" to pump up scientific growth in what [3] calls "vital areas of space science, technology and allied fields".

4. "Space Industry Capacity Building", to develop local capabilities of satellite development, on the model of what was done in Japan with PHL-Microsat.

5. "Space Education and Awareness", to develop training programs for space engineers and scientists. In particular, in November 2016 during the 23rd Asia-Pacific Region Space Agency Forum (APRSAF), the Secretary of DOST, Prof. Fortunato T. dela Peña announced the goal to "produce at least 800 trained aerospace scientists and engineers within the next 10 years" [14].

6. "International Cooperation", very important for the Philippines, which aims at becoming an important contributor to space development and space science in ASEAN and around the world.

[2]From average Peso to US Dollar exchange rate in August 2017: 1 peso = US $0.019637. Hereafter, all conversions will be done using the same rate.

	Type of satellite				
	GEO Telecom	LEO Telecom	Optical-Infrared	SAR	Microwave
Communications	■	■			
Agriculture			■	■	
Forestry			■	■	
Environment			■	■	
Urban Planning			■	■	
Climate Studies			■		■
Coastal Monitoring and Ocean Studies			■	■	■
Disaster Risk Reduction and Management	■	■	■	■	■
National Security	■	■	■	■	■
Flood Monitoring				■	■

Figure 1: Priority application for the Philippines, by satellite type [23]

4.3 Satellite applications and technology development roadmap

When drafting the main principles of the Filipino space development program, the NSDP analyzed in depth the comparative advantages of various satellite technologies to solve challenges facing the Philippines. The findings of this research were partially presented in July 2017 during a workshop in Jakarta [23], and can be found on figure 1.

Based on this, the NSDP established a key document for understanding technology policy: a satellite technology development roadmap (see figure 2), presented at the same workshop.

We can see a correlation between the data of the two figures with a priority given to the development of optical-infrared and SAR satellites, technologies having the widest applications, including the three axes adopted for the promotion of the Philippines' satellite development program: agriculture, environment and disaster risk management.

4.4 Short-term institutional changes

Over the next few years, the institutional framework of the Philippine space development could undergo several changes: the planned termination of the PHL-Microsat project and the possible transformation of the NSDP into a stable office.

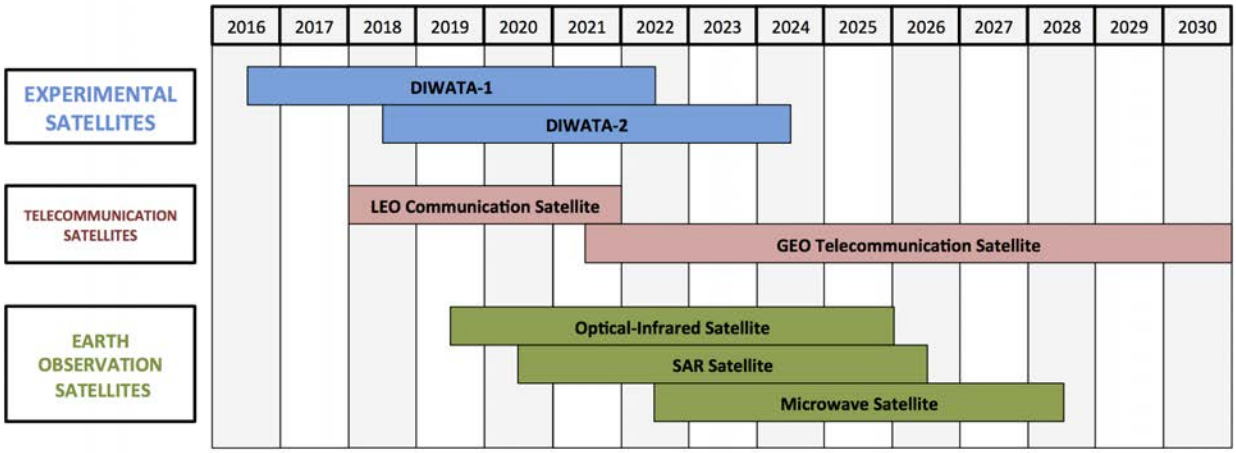

Figure 2: Technological roadmap for Filipino space development [23]

4.4.1 A National Space Development Office?

Apart from the support to Congress bills, one of the other paths currently followed by the NSDP is the promotion of an executive order for the creation of a National Space Development Office, in order to replace the current NSDP, which would therefore cease to exist. By replacing a "project" by a real "office" within the DOST, the executive order would create a more permanent and stable structure in charge of space development until the establishment of the PSA.

This "NSDO executive order" has already been drafted and submitted to the presidential office and is expected to be signed and to enter into force in the future [34].

4.4.2 After the completion of PHL-Microsat

As explained in 2.2, PHL-Microsat is a project aiming at the development, building and deployment of the two first Filipino micro-satellites, Diwata-1 and 2. Therefore, after its completion in 2018, symbolized by the launch of Diwata-2, the project will be terminated, irrespective of the status of the PSA bill [34]. While the satellites are the official property of the DOST and will be operated by Filipino actors (DOST as well as universities and research centers, before the establishment of the PSA), another important aspect is the expected future of PHL-Microsat project's researchers.

An important aspect regarding PHL-Microsat staff is that they all have very different profiles and affiliations. Some of them are students while others are researchers and teaching staff of Filipino universities. Although they are expected to continue to contribute to the Philippines' space development program in universities and later as PSA staff, they are not tied by any contractual clause [34, 35].

4.5 Status and roles of the PSA

The final important point to be raised concerning the Filipino space policy is the detailed explanation of the various expected roles of the PSA. In particular, the bills currently under evaluation in the Congress would order the PSA to "address space-related issues", "advance space science and technology research", "coordinate all national space activities", and "provide a framework for harmonious cooperation" [3].

More precisely, the PSA will be in charge of the implementation of all aspects of *The Philippine Space Development and Utilization Policy*, as described in 4.2. Section 8 of [3] explain in details the tasks and responsibilities of the PSA. An annual report of the activities of the PSA will have to be submitted every year to the Office of the President and to the Congress.

Concerning its status, [3] defines the PSA as a central government agency (section 6), attached to the Office of the President (section 9) and headed by a director general having the rank of *Cabinet Secretary* (section 10). The PSA is also expected to incorporate currently existing organizations in charge of space science, namely the *Philippines Aerospace Development Corporation* of the Department of Transportation and Communication, the *Manila Planetarium* and the *Philippines Space Education Institute* of the DOST (section 13).

Finally, the PSA will be granted an initial sum of 1 billion pesos (approx. US $19.6 million) from the Office of the President, the DOST and the Department of National

Defense. After this, the PSA budget will be included in the yearly *General Appropriations Act* (section 20). A grant of 2 billion pesos (approx. US $39.3 million) per year will also be provided during five years from the *Philippine Space Development Fund* (section 19).

5 Considerations from Innovation Policy

The considerable investment required to establish and sustain a space program historically discouraged developing countries [1], and so they relied on foreign assets and services (either purchased or offered) to provide useful data for governmental and commercial purposes. On the other hand, cost reduction phenomena associated to the *NewSpace* innovation trend seem to offer good chances for the development of domestic space capabilities with acceptable investments [26].

House and Senate bills proposing the creation of the PSA have shown awareness of the costs generated by the lack of a domestic space agency and industry [3–6, 20, 21], while not specifying the way to obtain a positive impact on the economy and society. In this section, we present a possible first step towards the definition of a suitable innovation policy for the Philippine space sector, to create a value-generating domestic industry without running into unsustainable costs for the government.

5.1 The relative benefits of 'Technology-push' and 'Demand-pull' strategies

The technology-push/demand-pull distinction classifies a certain policy depending on the funding approach chosen to pursue innovation in a given field. As ample discussion is given in the literature [2, 11], we will limit our definition to very fundamental concepts: a technology push policy pays for the development, a demand pull policy pays for the product. This can be alternatively described with the supply side policies/demand side designs dichotomy proposed by W. Edward Steinmueller [27]. It becomes very clear how the early stages of space development in most countries pursuing ambitious space programs (US, Russia, Europe, China, etc.) have been supported by policies of the first kind, as the great technological achievements needed would have been too risky and not commercially applicable for the industry. In recent years, however, demand-pull is gaining momentum, as it proved to be effective and cost-saving in a variety of fields. The commercial space contracts awarded by NASA in recent years are a clear example of such trends [28].

In this paper, we chose to use Dr. Sese's classification of "Areas for Future Philippines Space R&D" [22] and to try to identify which policy better suits each one of them:

1. "Space sub-system production": producing subsystems simplifies development by reducing the need for integration, a major obstacle for new entrants. Furthermore, due to limited export restriction, expertise in the field can be easily acquired with international cooperation, as the Diwata-1 case clearly shows. The gap to be filled by the domestic industry to become competitive being relatively limited, a demand pull approach might be appropriate for such components.

2. "Satellite assembly, integration and test facilities": with hardware complexity exponentially increasing with the number of components, it is hard to imagine the private sector taking the huge risk of investing in this field. A technology-push approach would be probably beneficial in early stages, possibly leveraging partnerships between industry and academia. Once fundamental capabilities have been domestically developed, a shift towards demand-pull would be desirable.

3. "Space applications and services": as they consist in software, usually cheaper than hardware, services using space infrastructure (domestic or foreign) while adding value by various means, such as big data and machine learning, can be supported from the beginning by demand-pull policies.

4. "Launch vehicle services and facilities": developing launch capability is probably the most challenging of the goals identified here. With export restrictions and strict intellectual property protection by foreign industry, international cooperation in early stages could be a difficult option. Due to the very large cost and risk, as well as uncertain and distant return associated with setting up a launch program, technology-push may be beneficial, mainly driven by the DOST and the Department of National Defense, as it will be further discussed in 5.3.

5.2 Universities' spin-offs

Supporting university spin-offs is a powerful method to extract value from university research [33]. The benefit of retaining a portion of the company ownership, the main economic benefit for private universities, is complemented, for public ones, by the broader goal of supporting national growth. US and Japanese governments, among many others, created policies facilitating university spin-offs and guaranteeing both direct

and indirect returns [24]. Various studies have tried to classify these phenomena, but only basic characteristics have been defined so far by the theory [15, 19, 24].

A university spin-off is, on a smaller scale, a transition between technology-push and demand-pull schemes. Government-supported university research necessarily adopts the first approach (as it would be impossible to take "entrepreneurial risk") to create breakthrough innovations. Once this has been achieved, supporting the creation of university spin-offs becomes demand pull, as the government signals its or others' willingness to pay for the output of this research.

The Philippine policy for university IP management is considered at a comparable level to those of other ASEAN countries, while still lagging behind the best practices [12]. While it's clearly hard for a Philippine university to offer breakthroughs comparable to those of other research powerhouses, the relative isolation of the space technology sector makes even smaller steps valuable. Under the DOST support, an improved scheme for university spin-offs supporting the technology goals of the PSA, and competitiveness growth for the country more generally, should be created following the policy transition discussed here. This would be especially beneficial for the development of local small satellite production capabilities, as it would address the previously discussed difficulties.

5.3 The development of LEO launchers for small satellites

In a presentation at the 23rd APRSAF in Manila, Philippines, the Secretary of DOST, Prof. Fortunato T. dela Peña, announced a series of long-term goals for the Philippine space development including the development of "indigenous rocket and missile launch capability" [14]. The association of rockets and missiles shows the focus of the Filipino government on LEO small satellites launchers. Contrary to inaccessible expensive large launchers for GEO satellites or interplanetary probes, LEO launchers are quite affordable and can be developed in parallel with missiles, being roughly similar equipment. Synergies can therefore be found between the DOST and the Department of National Defense on this specific goal.

Historically, rocket development has closely followed missile development (e.g. the German V2). Therefore, a close collaboration between military and civil actors on such goal would promise a quick and efficient development phase. Nevertheless, the development of launchers, even for LEO small satellites, is a complex problem, which would probably benefit from discussions with international partners.

5.4 The need for international cooperation

A key element for the Filipino space development is international cooperation. In particular for countries having limited financial means like the Philippines, it could be critical for the realisation of ambitious projects to find synergies with other established foreign space agencies. For the Philippines, this can be done in two ways:

1. At the ASEAN level, several countries are either willing to develop space technologies or are currently operating their own satellites. However, the greatest challenges facing the region (disasters, food insecurity, etc.) require much more than what can already been done with ASEAN countries' indigenous capabilities. A concerted effort of all space countries in the region could, first of all, help provide a stronger answer to these challenges and contribute to the quick and efficient development of space technologies in growing economies like the Philippines. There is no doubt that the experience gathered by Malaysia, Thailand or Indonesia during the initial stages of their space development programs can be of great relevance for the Filipino government.

2. The second possibility of cooperation is with rich and highly-developed space-faring countries such as the US or Japan, traditionally close to the Philippines. PHL-Microsat is a useful first step to initiate such partnerships through universities' academic cooperation. Nevertheless, much more can and should be done. The main advantages for the Filipino government in following this path is to accelerate the establishment of its space program by benefiting from technology transfers from foreign space agencies, research institutes and private companies, and by improving its pool of space engineers and scientists trained in foreign institutions.

As briefly evoked in 1, an interesting example of an institution established through a high level of international cooperation is the space agency of Bangladesh, the Space Research and Remote Sensing Organization (SPARSSO).

Conclusion and future works

Initiated in 2015 — after a failed attempt in 2012 and a comprehensive study carried out in 2014, the NSDP aims at laying the groundwork for the establishment of the PSA. Thanks to a reasonable while ambitious

Philippine Space Development and Utilization Policy as well as various roadmaps drafted by NSDP officers, important bills for the creation of the PSA were filed and are currently being discussed in both chambers of the Congress. These bills enclose most of the philosophy of the NSDUP, summarized in six *Key Development Areas* such as "hazard management and climate studies", "space research and development" or "space industry and capacity building".

Concerning the institutions themselves, while PHL-Microsat will be terminated after the completion of its goals — the launch of Diwata-2, NSDP is likely to be upgraded into an actual "office" within the DOST, before being integrated to the PSA after its establishment, expected from 2018.

From the point of view of innovation policy, several naive recommendations can be given but seem to have been already understood and integrated into the Filipino strategy:

1. While some degree of technology-push could be useful to initiate an embryo of space industry in the Philippines, a demand-pull approach should be favoured as it would ease the financial burden of the Filipino government. It is reasonable considering the country's R&D goals (development of bus and payload subsystems), and its interest in analytics.
2. The development of indigenous satellite development capabilities might also be facilitated by policies favourable to university spin-offs.
3. Launching capabilities should be limited to the more modest goal of LEO orbits by finding synergies between civil applications of the DOST and missile development by the Department of National Defense.
4. An accent should be put on international cooperation, not only with highly advanced countries like the U.S. and Japan but also with developing Asian neighbours to initiate a positive dynamic of parallel development in the Asia-Pacific region.

Finally, this case study on Filipino space development aims at opening a wider discussion on space development and space innovation policy in Asia-Pacific, about both past programs (e.g. Thailand or Malaysia) and future initiatives.

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Space-based Disaster Risk Management by Location-based Emergency Shelter Awareness and Training (LESAT)

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Abstract

Natural disasters have the potential to reverse years of hard-gained economic developments. In the wake of a disaster, preparedness is of critical importance to ensure that the victims can reach the nearest emergency evacuation shelter safely, quickly and efficiently. However, due to widespread communication blackouts and panic following a disaster there is often delay in deciding when, where and how to evacuate which could prove to be fatal. Location-based Emergency Shelter Awareness and Training 'LESAT' is a smartphone application that uses space-based location data like GPS and overlays it with Earth Observation satellite data to provide personalized training to individuals to make them better aware of the potential risks of disaster(s) in their current habitat, the location of the nearest emergency evacuation shelter(s) and the ideal evacuation routes to reach them. A model implementation of this application in the Philippines has been analyzed. The different stakeholders involved have been identified and potential incentives for each of them to participate in this project have been recognized.

Keywords: Augmented Reality, Disaster Risk Management, Earth Observation, GPS, Philippines.

1. Introduction

According to the report by United Nations Office for Disaster Risk Reduction (UNISDR), "just in the last 10 years, natural hazards have amounted to $1.4 trillion in losses due to total damage, affected 1.7 billion people and resulted in the deaths of 0.7 million"[1]. Defined by great damage, loss, and destruction in human lives, natural disasters are sudden and calamitous events, which create large humanitarian and development challenges. There is no country that is immune to these disasters, although vulnerability varies region to region. Asia-Pacific in particular fares worse owing to a multitude of factors such as its geographical location, relative economic poverty and high density of population among others. As the most disaster-prone region in the world, they suffer close to 40% of the globe's 'natural' catastrophes [2]. "Since 1970, more than 5000 major disasters have hit this region causing more than two billion fatalities and affecting the lives of more than six billion" [3]. Globally, we continue to see increasing trends in rapid climate change, warming temperatures, and financial costs. Indeed, climate change manifests itself through the hydrological cycle. With greater intensity, rainfall variability and glacial melt contributing to floods, storms, and sea level rise. Small island developing states as well as low lying coastal communities such as the Philippines are especially at high risk. As decades of economic development is often lost within a matter of minutes when a natural calamity strikes, reducing disaster risk and increasing resilience to natural hazards are mandatory requirements for sustainable development.

1.1. The Role of Space-based Data in Disaster Risk Reduction

Disaster Risk Reduction (DRR) is a cross-cutting issue in the 2030 Sustainable Development Goals (SDGs) with direct relation to at least 25 targets in 10 out of the 17 SDGs related to poverty, ending hunger, ensuring healthy lives, education, building resilient cities and climate change [4]. Preparedness is a crucial and perhaps the most important component of the DRR cycle, which also includes elements of prevention, response and rehabilitation in its full cycle. Although disasters are inescapable, their worst effects can be partially or completely prevented by the act of preparation. Early warnings as well swift and decisive strategies can offer timely responses that saves millions of lives. For example, it has been known for decades that it is much more effective to evacuate people before a flood than it is to rescue people during or after one. Providing relief to victims only after the disaster limits valuable opportunities to better absorb, recover, and build resilience from disaster shocks and stresses. It is essential to believe and work towards a culture of prevention and

risk reduction rather than just reaction and relief. In this context, Community-Based Disaster Preparedness (CBDP) approaches are increasingly important elements of vulnerability reduction and disaster management strategies. They are associated with a policy trend that values the knowledge and capacities of local people and builds on local resources, including '*social capital*'. Most often, CBDP are used to increase the resilience to a natural hazard by raising *awareness* of people to the disaster risks. This is because community members who perceive their lives and livelihoods to be especially vulnerable are more likely to cooperate in relevant preparedness initiatives [5]. Also, increasingly institutions and political frameworks are recognizing the benefits of using space-based data for DRR purposes. A prominent example is the Sendai Framework for DRR 2015–2030, which explicitly promotes the use of Earth Observation (EO) to gather data that is needed to elaborate information on hazard exposure, vulnerability and risk and hence as an indispensable source of information to support decision-making related to disasters. EO has been widely applied to disaster risk management (including disaster preparation, response, recovery and mitigation). Data collection and processing methods have advanced substantially. Freeing data archives ranging back over more than 30 years (for example Landsat/NASA) and EO programs like Copernicus provide a plethora of various types of satellite data and products. Such advances need to find their way in applications related to DRR, including in the indicators to monitor advances in these areas. EO from ground and space platforms and related applications represent a unique platform to observe and assess how risks have evolved in recent years, as well as to track the reduction in the level of exposure of communities to natural hazards over the years.

2. Emergency Shelter Awareness

Emergency evacuation shelters allow for a place of temporary safety, resources, and protection most profoundly against disasters involving immediate evacuation such as floods, storm surges, earthquakes, and fires. They play an absolutely vital role catering to the well- being of the displaced affected populations and act as the first promoter of rehabilitation. Once inside, people feel less panic and anxiety in the wake of chaos. Since shelters are usually equipped with stocks of food, water, and telecommunication, they play a key role in preventing loss of life. However, the evacuation itself, which may pre-empt an event or occur in the wake of an incident must be carefully planned beforehand so that it ensures the safest and the most efficient evacuation time of all residents. Otherwise, a disorganized evacuation can result in confusion, injury and property damage. One of the most common effects of a large disaster is the immediate massive blackouts caused in the existing communication channels due to telephonic congestion, power outage, road blockages, land inundation, infrastructure damage etc., resulting in extreme difficulties in effective evacuation. With special reference to disasters such as earthquakes, tsunami, storm surges, and floods where quick evacuation is of prime necessity, a matter of minutes to reach a safe shelter can mean the difference between life and death.

Research observations have shown that even if the choices for emergency evacuation centers exist, evacuation rates vary and not everyone leaves. The factors that affect such evacuation decision making process of the populace usually include perception and beliefs of the local community, finding the credibility of the warnings issued, reinterpreting the situation depending on past experiences, ignoring the warnings, level of education and average age of the population, desire to protect their property from the hazard etc. Such circumstances beg the question: What does it take to persuade people that warnings are issued only for their own safety and security? Studies in [7] state that, *people do not evacuate for several reasons including, but not limited to, past experience, traffic, immobility, lack of transportation, limited social capital and the desire to shelter-in-place.* (Mileti, Drabek and Hass, 1975).

It has been found that usually, the initial reaction to warnings of a disaster threat is skepticism, rather than panic [8]. If it seems that the warning is credible, the common reaction is an attempt to corroborate its validity, typically by listening to broadcasting media such as radio and television or by speaking to friends, families, or neighbors. If there is contradictory information or ambiguity concerning the threat, recipients of the warnings will tend to downplay the threat. Moreover, the members of susceptible populaces will exploit any "ambiguity" in a warning message that further allows them to reinterpret the situation in a nonthreatening way [8, 10]. Such attitude of people finally leads to a situation where there is a proportion of people who do not heed the warnings issued and are hesitant to evacuate which in turn causes pandemonium in spite of the availability of the evacuation centers. For example: *In Australia when interviewing residents that had evacuated during the Maitland 2007 flood, only 52% said they would evacuate in any future flood* (Gissing, Molino et al. 2008) [9]. One other example from Hurricane Andrew, South Dade County, Florida, 1992 shows: *while it is estimated that seven million residents evacuated, three million refused to leave* [10]. Another important factor is the educational level of the population which plays a major role on evacuation decision-making compared to income or occupational status (e.g., Moore, et al, 1963: 80-83) [6]. Similarly, age is sometimes also considered as a significant issue. Practically it is sometimes difficult for the aged people to rush towards the evacuation centres because of their poor physical condition even if they are

aware of the same. *Several studies indicate that those over 60 are less likely to leave than younger people* (Moore, et al, 1963; Smith, 1979) [6]. Hence, to combat all such tendencies of people, a greater focus on risk communication is required as a part of disaster preparedness in order to maximize evacuation rates and save millions of lives.

Our research shows that there are two major problems people face with respect to emergency evacuation and which may prove fatal:

Q1. When to Evacuate?

The timing which people choose to leave following a warning to evacuate is extremely variable. Murakami, Takimoto et al. [11] studied the case of 2011 tsunami in Japan, and found that 37% commenced evacuation during or directly following the earthquake, 31% evacuated sometime afterwards, 14% did so when the danger became obvious, while 18% did not evacuate at all. Petrolia and Bhattacharjee [12] assessed the intentions of people to evacuate in respect of hurricanes in the US. They found that 34% of those sampled, indicated they would evacuate, 28% would wait before deciding, 30% would not evacuate and 8% didn't know what they would do. A recent Nature article [13] reported that during the cyclone Nargis which had a casualty of 138000 in Myanmar, "all interviewed eyewitnesses ignored warnings owing to lack of cyclone awareness (...) the inundation penetrated 50 km inhibiting last minute evacuations". In another study [14], it was found that "Only 25% of people decided to go to safety shelter after an earthquake" (after 921 Chi-Chi Earthquake, Taiwan). Yet another study [15], confirms the fact "the occupant of the house, leaves only if he/she believes that his/her home would be affected". These and other similar trends reflect the inability of the public to understand and follow evacuation procedures.

Q2. Where to Evacuate?

Even if the community member decides to evacuate (bypass Q1), the ability to find the location of a safe emergency shelter within a typically short window of time is crucial. This window is smaller in economically challenged developing countries, making the awareness of the location of shelter and the time and route to reach it, an important requirement in a successful evacuation. Lack of such knowledge, can result in much larger number of casualties. For example, in our interview with Mr. Ven Paolo Venezuela, a Filipino DRM practitioner, it was found that in Typhoon Haiyan "perhaps half the 6000 deaths are unaccounted for – probably drowned from storm surge, and likely because they did not know the location of safe shelter and believed they were already in one". Although it is not a frequent incidence, but sometimes because of lack of knowledge of the surroundings evacuees involuntarily flee in the direction of greater hazard. Hence, it is of great importance to be familiar with the closest safe assembly area or nearby emergency evacuation center for safe escape.

2.1 Current DRR Practices

Disaster risk reduction is gradually being recognized as a major influence in achieving sustainable development, although it still remains a challenge to systematically integrate DRR into development planning and activities. [16]. At present different levels of preparedness initiatives exist in most countries. The wealth of developed nations permits them to allocate adequate funds for disaster mitigation and preparedness measures. For example, these countries encourage researchers to identify danger prone areas and recommend appropriate measures for safety and shelter by providing them adequate amount of money. The developed nations also create intricate training systems to prepare disaster response teams. Such training systems are kept accessible to everyone from first responders to community volunteers for responding to a crisis more efficiently and quickly. Furthermore, these countries exploit the best technologies and high-level education to develop warning systems for the common people [17]. Japan, the United Kingdom, the United States, Sweden, Australia, New Zealand etc. are the examples of developed nations that have advanced emergency management programs focusing on resilience. If we consider the instance of Japan, it is arguably the world leader in readiness. Every year since 1960, many Japanese schools, public and private organizations conduct region wide emergency evacuation drills on specific disaster awareness days. Such initiatives which are characterized by their large reach and high impact, help the country to top the list when it comes to disaster preparedness.

In comparison to developed nations, developing countries suffer more from natural disasters because of their weak warning procedures and impecunious living conditions. These countries usually lack sufficient funding, appropriate knowledge about disasters and enough equipment to diminish their vulnerability. However, in developing nations also, local disaster drills exist, which are often conducted by small organizations (such as a school or a university). Such drills are typically performed on a smaller scale and these are more flexible and frequent with a smaller reach, which require less investment. Nonetheless, currently there is a niche in the provision of direct and 'customized individual training' to each member in a community – one which is flexible, can have a large target audience and needs significantly less investment. The socio-technical system design we have developed here is one which would target this niche – in the context of training and empowering the

community to tackle the aforementioned difficulties during the necessity of an emergency evacuation

3. Location-based Emergency Shelter Awareness and Training (LESAT)

3.1 Rise of GPS enabled smartphone usage

The idea behind LESAT's design is to tap into 'pre-existing socio-technological behavior' prevalent in this 21st century – widespread popularity and usage of "smartphones". According to the Ericsson Mobility Report, 2016, the smartphone penetration in Philippines is around 40% with predictions of up to 70% by 2020. Our proposal combines this rapidly developing trend along with the necessity to provide customized information about emergency evacuation shelters to individuals utilizing the location awareness capability (GPS) present in a smartphone. Also in the absence of GPS in the phone, the approximate location could be identified by using triangulation between three or more radio towers.

3.2 Earth Observation satellite data

The usage of space technology and data in the DRR efforts has been on the increase. Earth observation provides advanced products and related tools that can be used to support risk analysis and risk reduction. Many countries face the difficulty of lacking environmental data. Ground-based monitoring systems like climate stations involve high costs, maintenance and data sharing policies. Therefore, they are often not available. Due to large-scale reprocessing activities, the archives of satellite imagery are constantly growing. We can access time series covering almost 50 years. This facilitates the assessment of underlying risk factors and impacts of global change over time. Satellite information is increasingly available for free. For example, data from LANDSAT, Sentinel, NOAA, ESA's EO Catalogue, INPE Image Catalogue, ISRO's Bhuvan- Indian Geo Platform, JAXA's Global Alos 3D World, Vitovision etc., are all available for free.

Table 1 shows the different satellite data types for different disasters and their corresponding data providers. The data providers are mostly branches of international space organizations like NASA, JAXA and ESA, which shows the importance of International Cooperation for Disaster Risk Preparedness and Response.

Since at the onset of disasters, communication lines may be affected, it is advisable to not have complete reliance on real-time updates for disaster response furthermore strengthening our earlier found niche that localized preparedness is very important for preventing loss in the aftermath of a disaster.

Table 1. Earth Observation data types and providers for DRR

DISASTER	DATA TYPE(S)	DATA PROVIDER(S)
Drought	Interferometric SAR Imagery	NESDIS NOAA, NDMC NASA
Earthquake	Ground-based Data, Interferometric SAR Imagery and GPS	USGS, JMA, Live Earthquake Map EMSC, Global Earthquake Monitor, Sentinel 1A, READI NASA-UCSD
Flash Flood	Visible and Infrared Imagery	NSSL NOAA
Flood	Radar Imagery	GPM NASA/ JAXA, GFMS NASA
Forest Fire	Visible and Infrared Imagery, LIDAR and SAR Imagery	Global Fire Map NOAA
Landslide	Ground-based Data, Interferometric SAR Imagery and GPS	USGS, DRIP-SLIP NASA, NASA Catalog of Global Landslide, GFMS NASA
Lightning	Visible and Infrared Imagery	NSSL NOAA
Snowstorm and Hail	Visible and Infrared Imagery	NSSL NOAA
Tornado	Visible and Infrared Imagery	NSSL NOAA
Typhoon, Cyclone and Hurricane	Visible and Infrared Imagery, GPS	TSR UC-London, NHC NOAA, JMA, CYGNSS NASA, CIMSS
Tsunami	Ground-based Data, Radar Imagery, and GPS	JMA, DART NOAA, PTWC NOAA, READI NASA-UCSD, POSITIM, Tsunami Alarm System
Volcanic Eruption	Interferometric SAR Imagery, Visible and Infrared Imagery	USGS, JMA, NOAA-CIMSS, ASTER & MODIS NASA, EUMETSAT

In this regard, historical database containing information regarding the effects of past disasters in a certain region can be of priceless importance. For example, users can have a guideline regarding the best way to access a shelter if they have an idea which streets are least likely to be flooded. This can be easily predicted looking at historical statistics of flood inundation levels in different streets of any given city from the open-access historical database in the websites of the data providers

in Table 1. LESAT will take into account this historical data and overlay with GPS data to develop customized disaster specific shelter information to the user. Thus, it can provide users the best possible route to access a nearby shelter from their location in the onset of a disaster since the shortest path shown by google maps to access a shelter may not be the best choice under such circumstances. Not only is this information useful during the onset of a disaster, but city authorities can also use this historical information to improve the resilience of city planning and rebuilding post the disaster.

In case communication lines are not affected during the occurrence of a disaster and users have internet access, LESAT will provide real-time disaster updates like actual flood inundation levels in the city, city traffic, congestion, estimates of the number of people at nearby shelters and warning signals in case evacuation is needed. Although Government, social media and news channels are expected to provide real-time information, it is always preferable to also have it automatically delivered via the Disaster Mode in LESAT. This makes Disaster Response more robust due to increased level of redundancy.

3.3 LESAT – The Concept

LESAT is a location-based technology (application/firmware) that provides customized information to its users and, since it requires the development of only an 'app', is of significantly lower investment and potentially massively scalable. LESAT works in 3 modes. 2 modes are used for training – before the disaster, and the final mode is used to provide customized info to the user in the aftermath of one.

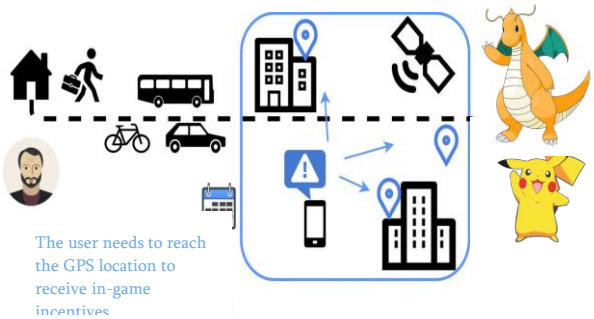
3.3.1 Training Mode 1: Passive - Sit 'n' See

In this mode, LESAT works along the following principle: On a designated day, nearby emergency evacuation shelters are shown to the user based on his/her current location (at home, at work or even during commute - this is important because in complex metropolis like Manila or Tokyo, people often travel long distances every day in their daily lives). LESAT would be active only on this day. The user can proceed with his/her usual daily activities. As he/she passes through pre-marked proximity 'zones' near the evacuation shelters (detected by the phone's GPS), a pop-up would be displayed in his/her phone notifications (with a photo and address of the shelter). In general, public buildings such as local schools, churches or city offices are generally designated as emergency evacuation shelters to be used in the advent of a major natural disaster. The user may choose not to interact with the LESAT pop-up. In case, he/she chooses to interact additional 'customized' information is displayed. The information would include the 'localized' severity of major disaster effects in that region– for example, water levels in case of a major flood, wind speeds in case of a typhoon etc. The data for the same would be obtained from national disaster management agencies of the country and also from pre-existing open databases of earth observation satellite data (Table 1). However, the government(s) in general always tend to follow a 'precautionary measure' with respect to disaster information dissemination. This means that the potential localized severity of a disaster may often be over-estimated resulting in the loss of faith of the public over the advisory, a phenomenon which can be termed as "cry- wolf". In order to mitigate this, actual occurrences of disasters in the area, in the past would also be displayed. Due to the passive nature of this mode, the cognitive bandwidth used by the individual is almost invisible, making this techno-policy solution a form of 'nudge'. With multiple such drills conducted in a year, we tap into the behavioral skill - 'memory' of the participant due to sheer repetition and exposure, resulting in his/her ability to locate the nearest shelter without any external support. This is especially advantageous in a situation where a communication congestion or blackout occurs. After a predetermined number of times of undertaking this training drill, the user may choose to opt out of the system after successfully answering a questionnaire which tests his/her knowledge of the location of the evacuation center(s). This also serves the purpose of a way to measure indirectly, the efficacy of this 'nudge' approach.

Fig. 1. LESAT Training Mode 1: 'Sit' n 'See'

3.3.2 Training mode 2: 'Play' n 'Go'

LESAT in this mode takes advantage of the prevalence and popularity of 'augmented reality' and applications based on it such as massively popular games – Pokémon Go, Ingress, Mario Run etc. It also taps into the 'human behavioural reward system'. It works in the following way: on the same designated day, emergency evacuation shelters are made as GPS markers which the user/player needs to physically reach in order to receive in-game incentives. This mode is more persuasive and it makes sure that the user knows not only the location of the emergency shelter, but also the means of reaching it – route and time, resulting in an additional layer of information. This info is understood not only cognitively but also "through his feet". LESAT in this mode can also be extended to train the user under different disaster scenarios. As an additional layer of challenge and also to make the user interaction more personal, real-life situations are simulated by adding a layer of uncertainty to the simulation. In the event of a disaster such as tsunami it is possible that some shelters are not accessible at all, some are not easily accessible by the elderly population and some are accessible only within a specific time window after the disaster. All these scenarios could be simulated under this mode of LESAT using in-game incentives or rewards. For example, some routes where potential blockages may arise post-disaster might be 'closed' in-game or given lower incentives, forcing people to take alternate routes. However, since one of the requirements for massive scaling of this app is being 'low-fat' in nature – meaning not requiring large volume of data for working, scenario simulations could be provided as add-on downloads. In order to implement this training mode, partnerships are required with developers of apps/games that utilize location knowledge and augmented reality. For example, Pokémon Go's Niantic is one prime candidate. However, this specific requirement of an external partnership is from a bane – the participating companies get crucial media exposure due to participation in such CSR activities resulting in a win-win situation.



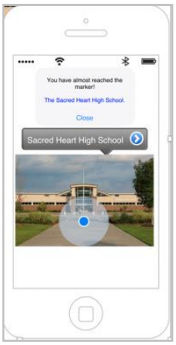


Fig. 2. LESAT Training Mode 2: 'Play' n 'Go'

3.3.3 Mode 3: Disaster Mode: Custom Info

LESAT also serves the user just before/after a major disaster strikes. If communication connectivity is possible, it displays customized information - direction & time - for reaching the shelter, in a simple, easy to understand format. This information is directly 'pushed' by the telecom service provider, in accordance with a mobile alert regulation, for reliable reception. Even if no or limited connectivity is possible, the mode will display the (time-stamped) latest known danger level, and saved names, addresses and contact info of nearest shelters to home and workplace, or other user-relevant locations. Crucially, any shelter displayed will be appropriate for the disaster at hand, e.g. "5-m storm surge", thanks to stored data on shelters, cross-checked with the latest disaster information. Finally, the danger meter will be calibrated to local historical events, paying special attention to not exaggerate the threat, or "cry wolf". If internet data connectivity is also available, based on the GPS location of the user, the government authorities are also notified when a user reaches a specific shelter location. This very valuable information can be used by the DRRM personnel to better understand not only the requirements at each shelter (for example, a shelter with more elderly need more medical care etc.), but also aid them in understanding the worst affected areas (for example, in case no one reaches any shelter(s) in a particular area, it is possible that they are not able to and hence need external help). However, to alleviate privacy concerns, either just the count of total people is provided or users (after an agreement) can provide their identities too. It is also interesting to know that once prior cached data of maps can be downloaded, the usage of GPS does not require the presence of internet connectivity. Therefore, even in the absence of internet communication, it is still possible by the by the user to know the direction to the nearest emergency evacuation centre.

Fig. 3. LESAT Disaster Mode 3: Custom Information

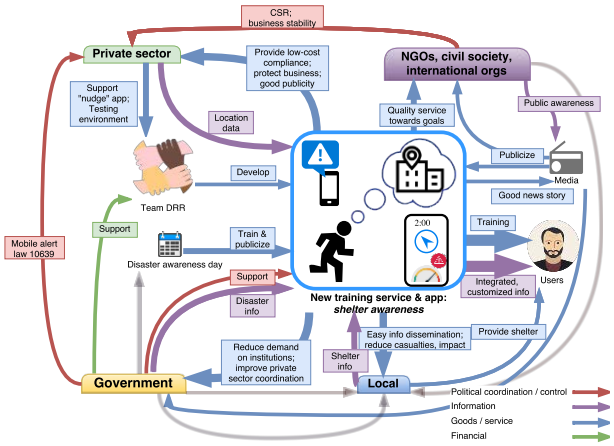


Fig. 4. Stakeholder map and interactions

4. Model Implementation in Philippines

A stakeholder map and value network for the LESAT system is shown below in Fig. 4. Firstly, it is important to note that the LESAT service is not just an app, but an integrated sociotechnical system coordinating several players and interactions. These players are shown here. In the centre is the LESAT training service and app, immediately to the left is *Team DRR*, for now our team, which is responsible for its development and execution. The other main players are grouped into the private sector, top left; government (assumed to be national level), bottom left; "local" (meaning especially local authorities and government), bottom right; and NGOs, civil society and international organisation ("3rd sector"), top right. Users are obviously key, to the right.

The main flows and flow type between groups are indicated. The principal ones are: information flowing from the private sector, government and "local" to LESAT, and then to the user; goods/service flowing back from LESAT to the private sector, government, local and also to users and civil society, and from the private sector to team DRR, and "disaster awareness day" to LESAT and "local" to the user; "political coordination/control" flowing from the government and civil society to the private sector. The minor flows include services going from Team DRR to LESAT, the media to civil society and government, and LESAT to the media; also, the only financial flow is from government the Team DRR development team.

The main idea is that LESAT requires data, services, and support or cooperation from many diverse actors; it should appropriately incentivize each of these actors to cooperate, by providing a service in return. Users are the main beneficiaries, but the self-interest of other stakeholder must be considered, in gauging their likelihood to aid. The government sector is the main client, as LESAT will reduce demand on its institutions, and so it provides financial support to the development team, Team DRR. It will also provide disaster information data to the LESAT system - this might be done via existing websites and information provision. Importantly, the government also provides some support, particularly moral and legal support for the system - official sanction. Government exerts relevant political control on the private sector with, in the Filipino case, Mobile Alert Law 10639. This law requires telecom companies to provide timely warnings to all its users, free of charge, in the case of a natural disaster. A further motivation for government support and funding is to help in improving coordination between the government and private sector, in accordance with this law.

Moving to the private sector, the main specific flows are receiving from LESAT the service of low-cost compliance with the mobile alert law, as well as protection of their business (clients, infrastructure, supply chains, employees...) and good publicity. It provides technical support to the Team DRR, including a testing environment, and importantly provides the critical location data to LESAT. Familiarity with this data, and ability to "push" data and apps directly to users is the rationale for the support role.

The local sector must provide shelter information, including number, location, and some characteristics of local shelters (e.g. suitability to type of disaster, access points, distance above sea level, capacity, contact information...). It is incentivized to do so by receiving the service of information dissemination that LESAT provides. LESAT should also reduce damage and casualty rates on local communities, hopefully incentivizing cooperation. It shouldn't be forgotten that it is the local sector that ultimately provides shelter to users in any scenario.

Civil society obtains a quality service in accordance with its aims, that is in disaster risk reduction. By being given the explicit opportunity to partner or associate with LESAT, it should be possible to obtain its aid in (a) public awareness of LESAT, (b) influencing Corporate

Social Responsibility (CSR) initiatives, to increase the likelihood of private sector engagement. In this way, the private sector can be approached on three fronts: (1) via government influence because of support for the project, (2) by self-interest, in complying with regulation cheaply and protecting their business, (3) via improving their public image. The third point can be broached from either the sponsorship/branding of the service, or via CSR budgets and activities, and perhaps via a mixture of both.

The media is an important player because of the important function of public awareness of LESAT. It can be incentivized by the providing of a "good news story" both by LESAT directly, and civil society, and in return can provide some publicity and awareness to the users. It must be pointed out that there are some network effects present here: the incentives of all players to aid LESAT is proportional to its user base and reach; this user base in turn is likely also proportional to the functionality and usefulness of LESAT, based on the resources and cooperation provided by these players. Because of this "snowballing" effect, the initial phase and gain of momentum (or user base) is critical and bears careful consideration. As such, we believe that another system, "Disaster awareness day", is worth considering. Coordinated by government, this is a multi-stakeholder event and platform for providing disaster-related information and training. A partnership with the government can aim to a high-profile rollout of LESAT at Disaster awareness day, in combination with other pre-existing measures. Such a strategy can reduce the risk of a "low-level trap" of user base in the early phase.

Finally, in this manner the user is provided with both training and *customized* and *integrated* data by LESAT. It is worth pointing out that most of the data required is pre-existing; the value generation of LESAT is by integrating it, packaging it, presenting the relevant parts and training the user with it. This is perhaps in accordance with current business wisdom: though *data* is typically not very valuable, timely and relevant *information* is extremely so. This transformation is where the main value addition resides.

It is worth looking at more detail of the different sectors, which are not unitary but composed of several interacting actors (Fig. 5.a). The government sector's disaster reduction efforts have, in the Filipino case once again, been recently conveniently centralized through the efforts of the National Disaster Risk Reduction and Management Council, or NDRRMC. This was in response to the fiasco of Typhoon Haiyan, which traumatized Filipino society in 2013 and demanded institutional reform. The NDRRMC serves to coordinate the efforts of several ministries and other agencies. The membership is extensive and includes representation from the Department of the Interior, the Department of Natural Resources and Environment, the Statistics Authority, and the Department of Science and

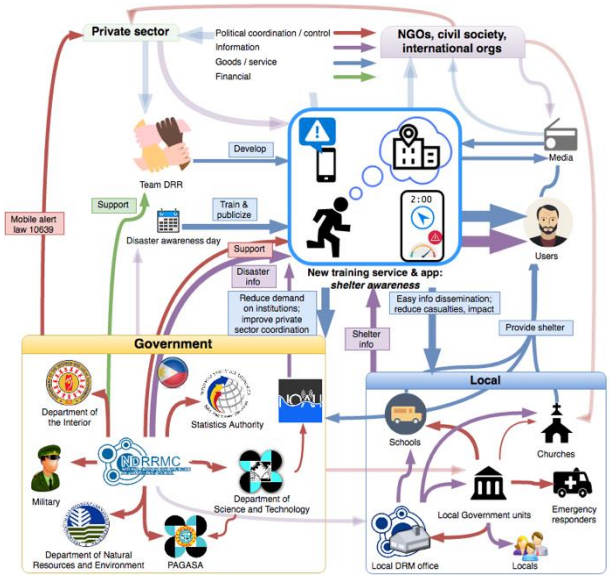


Fig. 5.a Detailed information on actors in the government and local sector

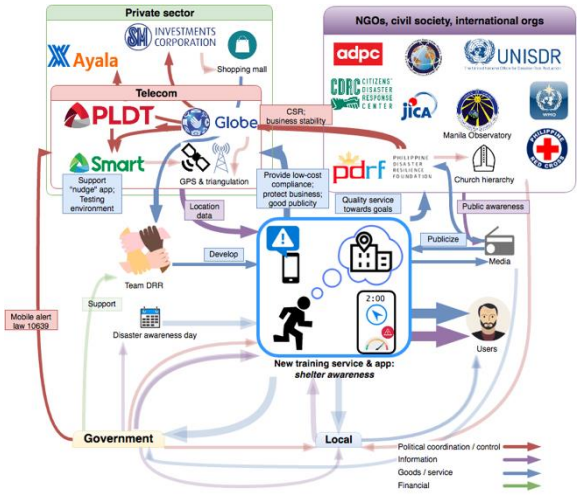


Fig. 5.b Detailed information on actors in the private sector and the civil society

Technology - with its agencies, the weather agency (PAGASA) and the notable project NOAH (on mapping and information dissemination, recently defunct). The overall leadership is assumed by the military. Vis-à-vis LESAT, the "one-stop-shop" of NDRRMC simplifies any negotiation, and potentially allows support from various government departments. It also testifies to the government priority that is disaster risk reduction. Project NOAH's heritage also simplifies the timely acquisition of up-to-date verified disaster data. Finally, the NDRRMC has direct links to local offices and government units, potentially facilitating simultaneous agreement and coordination.

Next looking at the organisation of local authorities, we note the most relevant actors as the government units and aforementioned local DRRM office, first responders, and schools and churches - the most typical shelters in the Philippines' (and many other countries') dual-use shelter system. This organisation likely facilitates DRRM office links to schools and first responders. However, it is likely that local authorities' control over churches is less strong, as such these should be dealt with differently than via government channels.

Looking at the Fig. 5.b, firstly within the private sector, we break down the relevant players into the telecom sector and the rest. Telecom companies, dominated by Globe and PLDT in the Filipino case, own and provide the GPS and triangulation data required for the functioning of LESAT. They also have the expertise needed to use such data, and push any notifications. Another relevant private sector player is SM Investments Corporation, the owner of a major shopping mall chain. Due to SMIC's commitment to disaster risk reduction, it has been suggested that these might be good testing grounds for the LESAT system. All companies listed here have their CEOs on the Board of the Philippine Disaster Resilience Foundation, a funded, voluntary and recent private-sector-led effort intending to demonstrate its intention to reduce disaster risk for society.

The civil society key player is the Philippine Disaster Resilience Foundation (PDRF), representing the private sector's DRR agenda. It will be the main point of contact for LESAT, and allow the coordination and streamlining of many important industry players' DRRM and CSR agenda. Due to its board being composed of the CEOs of said companies, it should be very influential. It is also important to point out that the Catholic Church hierarchy is also on the PDRF board, forming a good point of influence for the previously-mentioned parish Church shelters at the local level. Though the Church is a key player in Filipino society, it should also be noted that due to its unique history, Filipino civil society is uncommonly strong and well-developed. This strength should be utilized, through such organizations as the Citizens Disaster Response Center (CDRC) and the Manila Observatory and *many* grassroots NGOs which may help information dissemination and publicity about LESAT. Finally, international organizations may be key for significant LESAT functionality - notably the World Meteorological Organization (providing cooperation on weather information and warnings) and the UN Charter for sharing space data, foreign aid organizations such as JICA, and others already working on the disaster risk reduction problem and with rich experience, such as the Asian Disaster Preparedness Center (ADPC) and Filipino Red Cross.

However, the above stakeholders are definitely not an exhaustive list - we've only tried to list and organize the most important actors and interactions. For example, other international donors may be important such as the World Bank (provider of large loans for disaster response), foreign militaries and aid (notably US military aid and ASEAN cooperation), universities may have a helpful role in the development of the app, the medical and insurance sectors are interested parties, as are the IT sector, charities, banking, lawyer groups and trade unions.

5. Conclusion

LESAT is an innovative socio-technological solution designed to provide training for individuals to help them realize the necessity to evacuate and help them locate and access emergency evacuation shelters in the occurrence of a natural disaster. The training is customized to each individual, and provided through the use of location-based (e.g. GPS) smartphone application /firmware. In addition to the GPS data pre-existing space-based data such as risk maps for different disasters are also overlaid upon the location data to provide customized information about the relevant emergency evacuation shelter and evacuation route for each scenario. LESAT works in multiple modes with different levels of cognitive bandwidth required by the users in each mode. The passive mode is a form of ‘nudge’ and makes the user aware of the presence of an emergency shelter nearby and also its location. The active mode requires the user to physically reach the specified shelter under different scenarios. In return, the user is provided in-game benefits from different applications with which LESAT is tied to. In the disaster mode, customized info is repeated during disasters. A model implementation in Philippines is analysed through a detailed analysis of stakeholder map. Policies to implement are designed in a way such that that all major players have incentives to participate and gain from the implementation. LESAT is a low-investment and highly scalable solution for improving the preparedness of the community to the adverse socio-economic impacts of natural disasters.

Acknowledgements

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End of AY 2017 Report for SIP – Group 4

Project Title

Disaster Management for the Future: Technological packages for Natural Disasters

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
16101	Seungju Seo	Engineering	Mechanical Engineering	M2	Leader
16119	Shunichiro Nomura	Engineering	Aeronautics & Astronautics	M2	Leader
16209	Kaittisak Kumse	Agricultural and Life Science	Global Agricultural Sciences	M2	Member
17107	Nobuhiro Funabiki	Engineering	Aeronautics & Astronautics	M1	Member
14106	Yuri Yoshihara	Engineering	Nuclear Engineering and Management	D2	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

The social issue we address in this project are the frequent natural disasters in Southeast Asia, which has interfered with its sustainable development. The goal of this project is to think about ways to prevent/mitigate natural disasters in Asia - with a special focus on Southeast Asia - using space-based assets. This proposed program aspires to achieve this via two-pronged holistic approaches. One is to evaluate the demand for managing and mitigating natural disasters in Southeast Asia. The other is to design a feasible observation system for natural disasters considering supply and cost-profit calculations. And the “technological package” is a concept of our way of solving social issues. Generally, space technology itself can not contribute to application field easily, and it is difficult to be handled in developing countries because of its difficult operation and management, as well as expensive use of the observed data. Thus, we provide our solutions as “technological packages” with concrete business model and economic efficiency.

Method: Explain through what kind of approaches you tried to achieve the objective.
*About the list and details of the interview, add the appendix.

[1st-year approaches]

First, in order **i) to clarify the concrete demands for managing/mitigating natural disasters in Southeast Asia**, we tried to identify what kinds of damage and social problems have been caused by natural disasters there by categorizing the types of natural disasters and investigating some disaster cases, and summarized the statistics on damages caused by natural disasters. Besides, **ii) we investigated through several discussions and a bibliographic survey about what kinds of space technologies are effective to prevent the occurrence of natural disaster/mitigate damages from natural disasters or to minimize the disaster risk**, and found that a synthetic aperture radar (SAR) satellite technology could be a breakthrough in terms of its versatility for any situations caused by disasters. We confirmed the effectiveness of the technologies and determined how to utilize this technology while considering the limitation of the technology export, difficulties of analyzing the raw data, and cost-effectiveness. Finally, **iii) we made a business model as "technological package", which provides the SAR-satellite data to Southeast Asia as a package including not only raw data but also developing satellite observation systems, data collection/analysis, and information providing services**.

[2nd-year approaches]

Our project this year is focusing more on **iv) the output of this project to the society in order to verify the feasibility and further applicability of this technological package by getting feedback from specialists or multiple stakeholders including space agencies, technology developers, launch providers, investors, international organizations**. The International Astronautical Congress (IAC) is one of the largest conferences, and there are many specialists in that field attending every year. We refined our project to a more realistic one by receiving such fruitful feedback from specialists. Besides, **v) we shared our outcomes and what we have learned through this 1.5-year project with other GSDM students by opening an IEL on Feb.28**.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

In this project, we proposed a system of 14 small satellites with X-band SAR, which can be used to mitigate typical natural disasters in Southeast Asia: wildfires and floods. Compared to conventional SAR satellites such as ALOS-2 with a 14-day revisit time, the proposed system realizes frequent observation with a 2-day revisit time, enabling immediate imaging.

To investigate its economic feasibility, we calculated the total system cost, assumed three price scenarios, and analyzed the break even volume for two demand scenarios. The results of break even volume analysis showed that it is economically feasible in some scenarios if the price is more than 1.0 USD/km^2, and in all scenarios if the price is more than 1.5 USD/km^2.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense (JPY)**
Attendance at the International Astronautical Congress - air tickets	208,000
Attendance at the International Astronautical Congress - other expenses	90,800
Total	298,800

*See the appendix for the details.

Appendix (Option)

We submitted the following paper to the 68th International Astronautical Congress (IAC2017). We had a presentation there and received some feedbacks from audience.

① Nowadays, more and more companies are actively trying to launch a business employing SAR system. ② Providing only raw data of SAR information should not be competitive in the satellite image market. The price of raw data should go down near future. ③ Some of Southeast Asian countries are now cooperating with the universities regarding analyzing SAR data. So, our product should be very sophisticated to play a dominant role in SAR image market. ④In terms of hardware, Southeast Asian countries are not well equipped with the technology to produce SAR-mounted small satellites. Japanese companies can make use of their technological advantages to pioneer the SAR-based industry.

Monitoring of Natural Disaster based on Synthetic Aperture Radar (SAR) Satellite in Southeast Asia

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Abstract

Southeast Asia is a region that is severely affected by a variety of natural disasters, such as typhoons, heavy rain, earthquakes, and volcanic eruptions. Synthetic-Aperture Radar (SAR) has a large advantage in speed of data acquisition and observation because it can observe in the night or through clouds. SAR has been implemented only on large satellites so far. However, recently, a new concept of SAR and a high-speed downlink system using single small satellites has been developed. This technology can drastically decrease development costs of SAR satellites, increase the frequency of observations using a constellation of SAR satellites, and enable many developing countries to have SAR satellites. Moreover, this technology enables Southeast Asian countries to construct a shared rapid disaster observation system internationally.

In this paper, a possible business model from the viewpoints of Japanese manufacturer and governments that utilize a feasible SAR satellite system based on MicroXSAR is described. A cost-benefit analysis is conducted and presented from the perspective of the manufacturer. Besides, the price of the whole observation systems is also calculated using a cost-estimation method of satellites, and is evaluated from the aspects of economic powers of Southeast Asian countries.

Keywords: Synthetic Aperture Radar, Southeast Asia, Small satellites, Disaster Monitoring

Acronyms/Abbreviations

GSD: Ground Sample Distance, SAR: Synthetic Aperture Radar, SSO: Sun-Synchronous Orbit, USD: United States Dollars

1. Introduction

1.1 Conventional Disaster Monitoring System

Optical and thermal-infrared remote sensing techniques mounted on satellites have been used for various Earth monitoring missions. Optical remote sensing can be applied to health monitoring of forest, farmland, waterside and so on, whereas thermal-infrared remote sensing is utilized for monitoring temperature distribution of grounds and sea surface, activities of volcanos. Though optical and thermal-infrared remote sensing techniques have contributed to the Earth observation, they have several disadvantages. The most remarkable demerit is that the observation is impossible in the night or when clouds cover the grounds. In addition, the resolution is relatively lower than that of microwave remote sensing. Therefore, optical and thermal-infrared remote sensing are not suitable for disaster monitoring because it is necessary for disaster monitoring to monitor Earth continuously in order to detect disasters rapidly. To compensate for the disadvantage of optical and thermal-infrared remote sensing, SAR technology has begun to be noticed as the solution.

1.2 SAR

Nowadays, SAR is a key technology for many kinds of scientific, commercial and disaster-managing applications aiming to produce high-resolution images of the Earth surface. The technology of SAR utilizes the flight path of the platform to simulate a large antenna electronically and produces the two-dimensional images of the Earth surface. It is suitable for monitoring missions because it generates the images independent from daylight, cloud coverage and weather conditions. For this reason, many space-borne SAR systems have been developed and operated in recent years. [1-3]

The Japanese SAR satellites, ALOS series, have high performances of mapping and precise regional coverage for disaster monitoring. [4] ALOS series contributed to disaster monitoring in various disasters in Southeast Asia as well as in Tohoku Earthquake in 2011. However, because the Japanese government always has had just a SAR satellite on a SSO, highly frequent and robust observation systems have not been constructed or provided.

1.3 Small Satellites

In the recent years, the industry and developments of small satellites have been growing rapidly. [5] That is mainly because the cost of manufacture and launch of small satellites are considerably cheaper than conventional large satellites. This feature makes it possible for small start-up companies to develop and produce satellites by themselves. Small satellites have the potential to widen the fields of their activities. In addition, they are suited for making constellations because they are superior to large satellites in terms of system redundancy and individual cost.

When it comes to the use of satellite constellation, small satellites have many advantages. For example, they can implement the observation of some kinds of events with high-frequency revisit time and wide ground coverage without high development cost.

1.4 Potential Application

SAR technology with small satellites could be potentially used to tackle many social issues. In the area of disaster management, SAR could be used as part of disaster monitoring and relief operation. For

example, SAR could be used for flooded area mapping, fire disturbance and monitoring, landslides monitoring, earthquake and volcano monitoring, drought monitoring, ocean wave height and direction measuring, wind speed measuring. Moreover, SAR can be used to enhance food security by providing useful information for potential food crises. For instance, SAR could be used for drought early detection, crop monitoring, crop production forecasting, crop biomass measuring, soil moisture measuring and crop classification. In addition, SAR could also be used for urban management such as urban and infrastructure planning, urban growth and road traffic monitoring. [6]

1.5 Purpose

In the potential applications of SAR technology, prevention and mitigation of natural disaster in Southeast Asia is one of the most attractive application in terms of social contribution.

Southeast Asia is the most disaster prone region in Asia and is facing with the rising number of natural disasters. Between 2000 and 2016, 855 disasters were reported in Southeast Asia, accounting for 31 per cent of Asia's 2,769 disasters (see Fig.1). Moreover, 362,323 natural hazard-related deaths were recorded in the region, 47% of the Asian total. Furthermore, the region incurred more than 109 million USD in economic damage over the same period, equivalent to an average 6.1 million USD loss per year. In addition, the number of natural disaster in Southeast Asia has been significantly increasing since 1960 (see Fig.2). Particularly, flood and storm have been noticeably rising, both accounting for 68% of the total disaster.

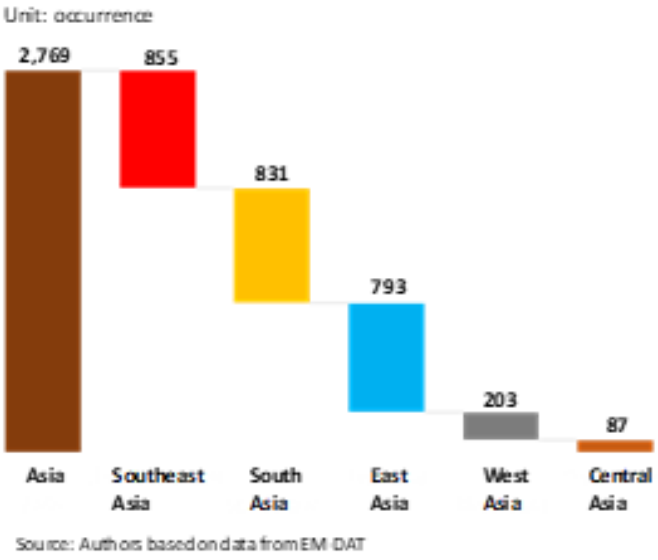

Fig. 1. Natural Disaster Occurrences in Asia

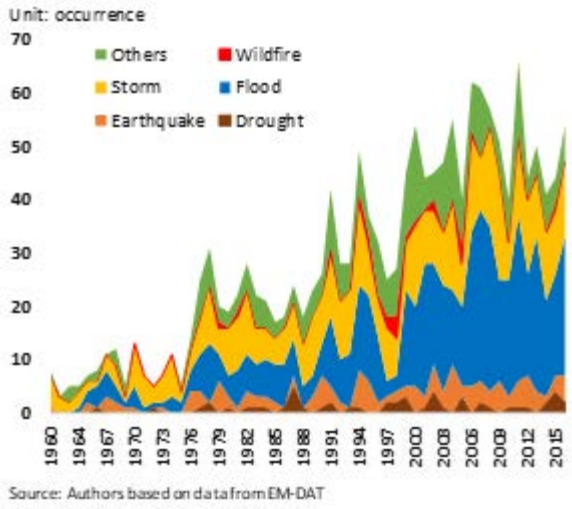

Fig. 2. Trend of Natural Disaster in Southeast Asia

In this paper, a possible business model from the viewpoints of Japanese manufacturer and governments that utilize a feasible SAR satellite system based on MicroXSAR is described. In our project, the natural disaster in Southeast Asia is focused on as a target application as a case study. A cost-benefit analysis is conducted and presented from the perspective of the manufacturer. Besides, the price of the whole observation systems is also calculated using a cost-estimation method of satellites, and is evaluated from the aspects of economic powers of Southeast Asian countries.

2. Proposed System

2.1 System Overview

In this section, the outline of the proposed business model is mentioned. Fig. 3 shows the system overview of the proposed business model (The procedure images of the data processing in Fig.3 are cited from [6].). The model contains four sections, that is, satellite developments and production, launching and orbit insertion, data processing, possible customers.

The blue section indicates the developing and production system of the satellites and the relationship between the system integrator and the component producers. A commercial small satellite company is in charge of the system design and manufacture of the small satellites with the SAR system. The company develops and produces the satellites in accordance with the design requirement of a data processing company indicated as the green section. The SAR sensor is the most important component and should be developed in accordance with this business model. The specification of the satellites is discussed in detail in 2.2.

As mentioned above, the green section shows the business description of the data processing company. This company makes the SAR images delivered from the satellites into useful information on the basis of customer's demand. The company is also in charge of the satellite operation. In order to acquire profitable information for customers, it is better that the company is capable of operating the satellites in line with what kinds of data customers want. The most important role of the company is the data processing which converts SAR raw data into useful information for customers. 2.3 shows how the data processing is achieved in terms of technology.

At last, the red section indicates the possible customers in this business framework. There are many possible customers, and they can be classified by the type of the application: prevention or mitigation. 2.4 provides the concrete explanation of the possible customers.

For the sake of clarity, we focus on measurement of forest biomass level for prevention of wildfire and detection of the flooded area for damage mitigation in this paper.

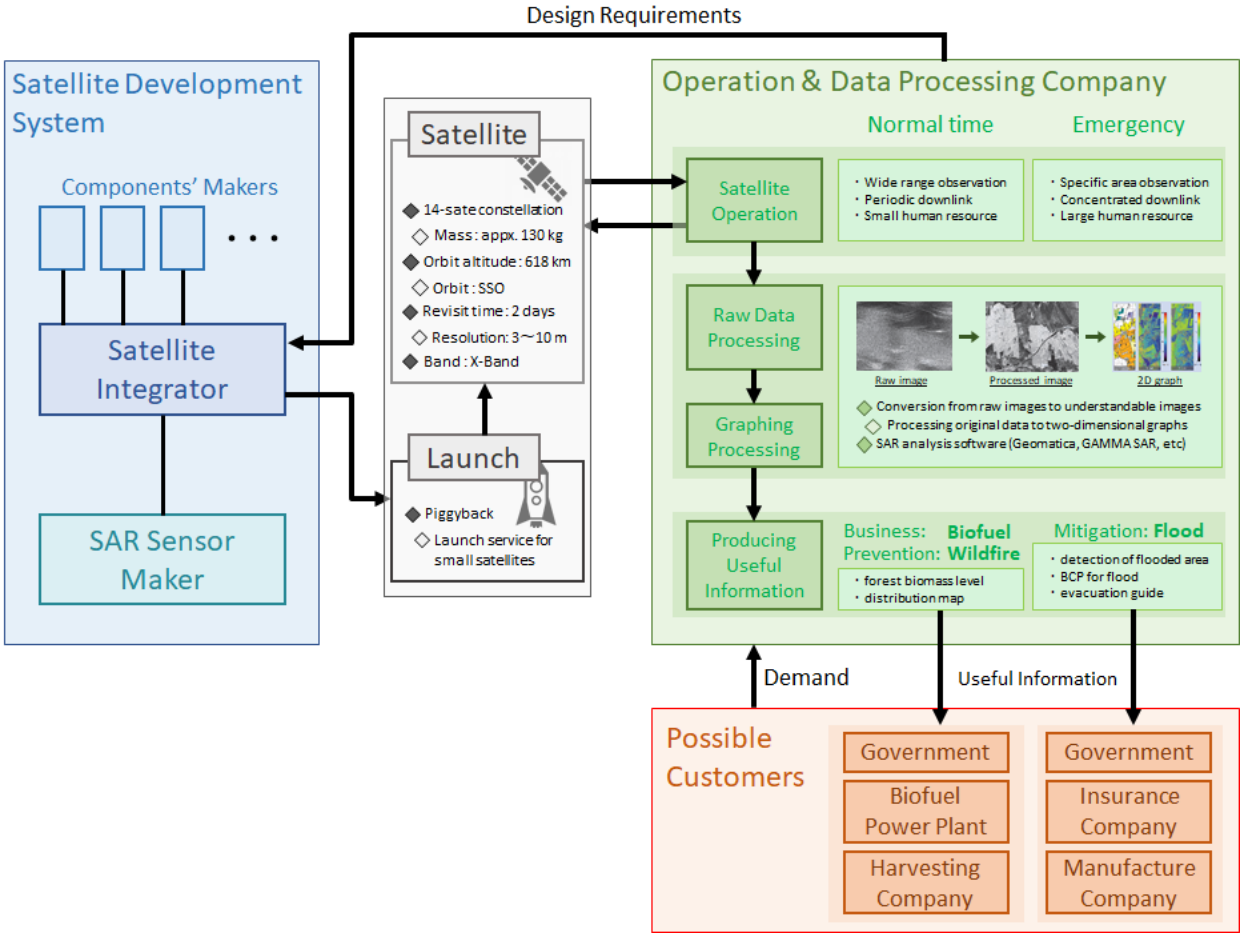

Fig. 3. System Overview

2.2 Small Satellites with SAR

This section presents the specifications of the proposed small satellite constellation for SAR observation and compares them to that of ALOS-2 [7].

The proposed system consists of 14 small satellites as a constellation in a SSO. Compared to conventional large satellites such as ALOS-2, small satellites cannot be equipped with a large antenna or a large solar panel to generate high power. Therefore it is relatively difficult to realize a high-resolution observation. However, since one small satellite costs much less than a large one, it is possible to form a constellation to realize a short revisit time, which is crucial to disaster detection and monitoring.

Table 1 shows the specifications of the proposed system compared with ALOS-2. We adopt MicroXSAR, a 130-kg small satellite with an X-band SAR proposed by Saito et al. [8], as satellites for the proposed system. The proposed system cannot achieve as long swath as ALOS-2 to realize the same image resolution. However, it succeeds in shortening the revisit time from 14 days to 2 days by employing 14 satellites as a constellation.

In case of emergency, a satellite can change its attitude to observe the area of interest. This maneuver can shorten the time between the event and the observation to 2.1 hours.

Table 1. Satellite System Specifications Compared with ALOS-2

	Proposed system	ALOS-2
Satellite mass	130 kg	2 tons
Orbit	SSO (Altitude: 618 km)	SSO (Altitude: 628 km)
Swath (observable)	28 km (~650 km)	50-70 km (1160 km)
Band	X-band	L-band
SAR image resolution	10 - 3 m	10 - 3 m
Number of satellites	14	1
Revisit time (observable)	2 days (2.1 hours)	14 days (16.2 hours)

2.3 Operation & Data Processing

Compared to optical sensors in satellites, SAR data needs to be transformed in a somewhat useful way to be fully utilized. In our model, SAR data processing consists of following steps. First, raw data from microsatellites is acquired. (The frequency of data acquisition from satellites should depend on its purposes; prevention or mitigation of natural disasters) Second, we transform raw data from satellites to graphical data implementing a commercial software.

The output of this step can either be a final product of our model or there can be an additional treatment regarding customer requirement. For example, we can carry out time series analysis based on our SAR dataset since our system has more frequent revisit time of 2 days than the conventional satellite systems visit time of 14 days. Moreover, we can further adjust it to the customer demand.

2.3.1 Prevention of natural disasters (Normal Operation)

Among possible applications of our model for preventing natural disasters, in this paper, we will focus on the prevention of wildfires based on forest biomass level. Backscattering coefficient data (σ^0) from SAR has been known to be able to measure forest biomass level. [9] Forest biomass refers to all above-ground plant material. It can include small or dead trees, shrubs, and the tops, foliages. Since these materials are typically left on the forest floor and easy to be a potential fuel for spreading wildfires, clearing out these materials with biomass harvesting can be helpful to either suppress the outbreak of wildfires by preventing the fire from spreading around, or lead to smaller wildfires around the nation. By monitoring and graphing forest biomass distribution from SAR data, biomass harvesting can be carried out in more efficient ways in terms of allocation of resources and time compared to conventional harvesting way. For example, given the biomass

distribution or time series analysis of biomass from our system, they can prioritize their allocation of harvesting machines or operators on duty. [10,11]

2.3.2 Mitigation of natural disasters (Emergency Operation)

In addition to the normal operations such as biomass observation, the proposed system can be used for mitigation of natural disasters such as flood, earthquakes, and volcanic eruptions. This section describes how the proposed system can be applied to estimate the flooded area as an example.

The luminance value of the backscattered wave of the SAR image varies before and after the flood. This is because the microwave reflects specularly with respect to the water surface.

Geometric corrections and the difference analysis of the luminance value are performed on the SAR image. This can lead to a quick estimation of the flooded area at the time of flood occurrence. [12,13]

2.4 Customer

There are many potential customers targeted in this business. Table 2 shows some examples of potential customers and demands. For biomass imaging, main customers are subcontractors of the companies of biofuel power plant. In Southeast Asia, According to conservative estimates, the amount of biomass residues generated from sugar, rice, and palm oil mills is more than 200-230 million tons per year which corresponds to cogeneration potential of 16-19 GW [14]. Biomass has two origins. One of them is "Agrofuel," which is from crop harvesting and other kinds of by-products from agricultural activities left in the field. Another is "Wood-fuels", which are Wood from forests, shrubs and other trees used as fuel [15]. The production of biomass is mostly commercialized in southeast Asia these days, and the consumption of Woodfuels has been gradually reduced because of shifting to other energy resources. However, there is potential motivation to reduce the dense forest. There is a report that woodfuels, especially tree modality due to insects might cause wildfire [16]. Visualizing biomass could help not only with efficient collection of biomass but also with preventing wildfire.

As an application to floods, we provide the information of the damaged area and evacuation guide, which could be useful for government and local government. Besides, if the information is provided via mobile applications, people could easily have access to the information. Also, potential customers including insurance companies and manufacturers might be interested in how much damage would be estimated by the disasters.

Table 2. Potential customers and demands

Customer	Demand (application)
Biomass	
Biofuel power plant	Visualize biomass distribution
Harvesting company	Visualize biomass distribution
Government	The possibility of wildfire to cleanup
Forestry/Farmer	Visualize biomass distribution

Flood	
Government	Damaged area (infrastructure, etc.) to let people evacuate
People	Evacuation area (safe area) and path to evacuate correctly
Company (manufacturer etc.)	Damaged area to carry products with less delay
Insurance company	Trends of flood and its damage to estimate the insurance fee for the flood.

3. Cost Calculation

3.1 Manufacturing and Launch

Though SAR is a well-known remote sensing technique with reliable capabilities that offer advantages over an optical sensor, SAR sensors require relatively large antennas with several meters. Thus, large or medium size satellites with hundreds kg or more have been used for SAR sensors. These large or medium satellites cost 100M USD including launching cost, which limits the number of potential customers.

The current technology of SAR that has 10-3 mm ground resolution with 4.7x0.7 m2 can be mounted on small satellites with 100 kg. These cost 10-20M USD including launching cost [17].

3.2 Operation & Human Resources

After manufacturing and launching our satellites with SAR, operation and human resources are needed to maintain the system. Table 3 indicates the cost-details of operation and human resources of our system.

Table 3. Cost Calculation of Operations and Human Resources

Operation			
	Num.	Cost [USD]	Details
Image-Processing Software	1	3,000	Commercial Software (ex. Geomatica)
Computer	10	20,000	Enough to operate commercial software
Miscellaneous expenses	-	10,000	Tables, Office rents, etc.
Total	-	33,000	-
Human Resources			
	Num.	Cost [USD / year]	Details
Software Engineer	3	150,000	Image Processing, Platform Service
Hardware Engineer	2	100,000	Radio Frequency, Electromagnetic Interference

Finance	1	50,000	FP&A Analyst
Company Operation	1	50,000	Administrative Assistant
Project Management Office	1	50,000	Technical Program Manager
Quality Assurance	1	50,000	Quality Engineer
Sales	1	50,000	Customer Service, Representative
Total	10	2.5M (5 years)	-

4.Feasibility analysis

4.1 System design cost

In accordance with the previous sections 2 and 3, the cost and price of the images from our system are estimated in this section. The lifetime of small satellites is known to be less than 10 years. Therefore, we estimated the cost and price of this system under the assumption that the satellites work properly for 5 years. The initial cost for operation is 33,000 USD from the section 3.2. The annual cost for employment is set to be 50,000 USD per person, and 10 people which include engineers and managers are necessary for the proposed system. Therefore, the cost for human resources is 2.5M USD for 5 years. The manufacturing and launch cost of one small satellite is estimated about 10M USD in section 3.1. In the proposed system, 14 satellites form the constellation; thus it costs 140M USD to prepare the constellations. As a result, the total cost of the whole system is about 140.3M USD, which should be recovered within 5 years. (Table 6)

Regarding our system, we assume two cases for applications under 3 different Market Share Assumptions (MSA) (Table 8) and carry out Break Even Volume (BEV) analysis under 3 different price scenarios (Table 7). As case 1, we assume 40 percentages from the area of Southeast Asia should be affected by natural disasters and stakeholders of those regions can be our potential customers to mitigate the damages from natural disasters. As a case 2, we assume that our system can also be utilized for flood-prone areas as well as forest areas in Southeast Asia. The image cost per area is estimated from the area of some regions customers are interested in and the cost mentioned above.

For case 1, we made an assumption that 40% of the area of Southeast Asia should be affected by natural disasters. According to Table 6, the total land area of Southeast Asia is 4,326,131 km^2. Therefore, 40% of the area is 1,730,452 km^2. We assume that our system will be utilized 30 times per year to get the images of those areas. Based on the assumptions mentioned above, we found out the total cost of our system can be covered within 5 years under two conditions; price scenario 2 with MSA 3 & price scenario 3 with all MSAs.

For case 2, we assumed that our system can be employed for both flood-prone areas and forest areas of Southeast Asia. As flood-prone areas of Southeast Asia, Table 4 indicates the percentage area in each flood hazard category [18]. From the data of Table 4, the area prone to flood damage is calculated as 792,007 m^2, which is equivalent to 17.7% of the total area of the ASEAN countries. As forest areas of Southeast Asia, Table 5 indicates the percentage area of Southeast Asia and its coverage. From Table 5, total forest area of Southeast Asia is 214,064 km^2, and its coverage is 49% of Southeast Asia. According to our assumptions, we

found out that the total cost of our system can be covered within 5 years under 3 conditions; price scenario 1 with MSA 3, price scenario 2 and 3 with all MSAs.

Considering market price of SAR images from Table 10, the image price itself of our system which ranges between 0.6 ~ 1.5 is higher than conventional market price. However, our products should be provided with additional or on-demand data treatment as well as better resolutions (3 ~ 10 GSD).

Table 4. Percentage Area in Each Flood Hazard Category of the ASEAN Countries

	Total Area [1000 m^2]	Extreme [%]	High [%]	Mod [%]	Flooded Area [km^2]
Brunei	5.765	0.75	0	0.75	86
Cambodia	181.0	26.9	6.49	5.43	70,264
Indonesia	1,905	2.39	3.32	6.04	224,000
Laos PDR	236.0	6.98	6.25	5.25	43,760
Malaysia	330.0	2.45	5.32	6.54	47,338
Myanmar	676.6	9.76	5.29	5.68	140,259
Philippines	300.0	7.82	2.43	0.95	33,600
Thailand	513.1	15.7	6.95	2.84	130,687
Vietnam	331.2	23.0	5.06	2.84	102,175
Total	4,481.0	-	-	-	792,007

* The data of Singapore is not included in the list because there is no effective data for flood damage in the country and the area is much smaller than the other countries.

Table. 5 Forest Area & Cover of Southeast Asia [19]

	Forest Area [km^2]	Forest Cover [%]
Cambodia	10,094	57
Indonesia	94,432	52
Laos PDR	15,751	68
Malaysia	20,456	62
Myanmmar	31,773	48
Philippines	7,665	26

Thailand	18,972	37
Vietnam	13,797	42
Southeast Asia	214,064	49

Table. 6 The Cost Calculation Result

Initial Cost [USD]	33,000
Operation Period [years]	5
Annual Cost [USD/year]	500,000
Number of Satellites [satellites]	14
Satellite Manufacturing Cost [USD/satellite]	10,000,000
Total Cost [USD]	140,300,000
Area of Southeast Asia [km^2]	4,326,131
Revisit Time [days]	2.0

Table 7. Price per unit and Break Even Volume on Price Scenario

	Price per unit [USD / km^2]	Break Even Volume [km^2]
Price Scenario 1	0.6	237,555,000
Price Scenario 2	1.0	142,533,000
Price Scenario 3	1.5	95,022,000

Table 8. Market Share Assumption (MSA)

	MSA 1 [%]	MSA 2 [%]	MSA 3 [%]
Year 1	20	30	30
Year 2	30	40	50

Year 3	40	50	70
Year 4	50	60	90
Year 5	60	70	90

Table 9. Case Analysis

Case 1 (40% of Southeast Asia is affected by natural disasters)			
Observed Area per one visit [km^2]		1,730,452	
Observation frequency per year [times]		30	
Total observed area per year [km^2]		51,913,572	
Case 2 (Biomass + Flood-prone area of Southeast Asia)			
Biomass		Flood-prone Area	
Observed Area per visit [km^2]	792,007	Observed Area per visit [km^2]	2,140,640
Observation frequency per year [times]	30	Observation frequency per year [times]	30
Total observed area per year [km^2]	23,760,230	Total observed area per year [km^2]	64,219,200
Total observed area per year [km^2]		87,979,430	

Table 10. Market Price of SAR Images [20]

Satellite	Image / GSD [km / m]	Price [USD / km^2]
ALOS	70 x 70 /10 or 20	0.18
TerraSAR-X	100 x 100 / 16	0.34

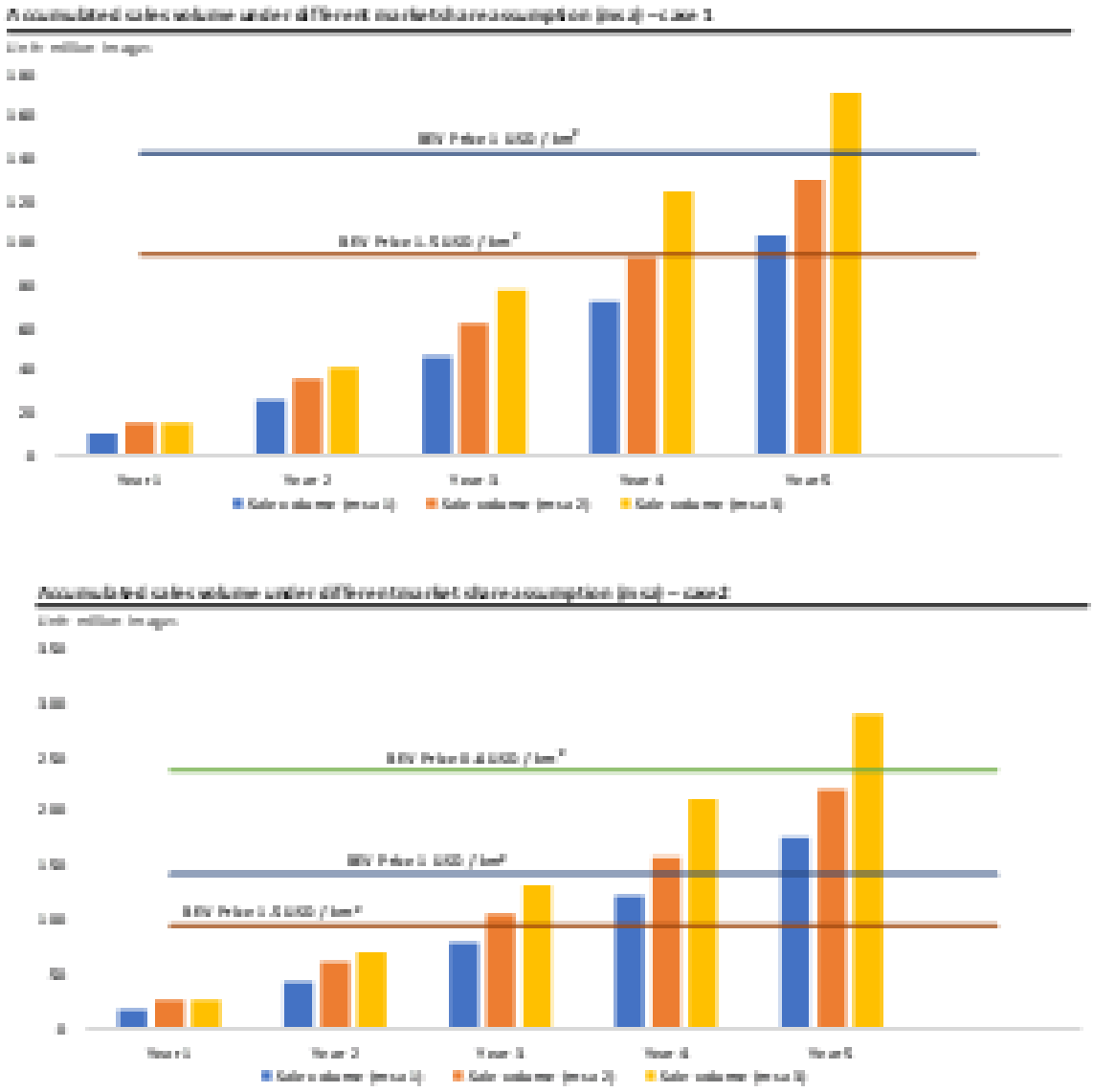

Fig. 4. Break Even Volume Analysis

5. Conclusions

We proposed a constellation of 14 small satellites with X-band SAR. By employing multiple satellites, the proposed system realizes short revisit time compared to conventional large SAR satellites such as ALOS-2 and TerraSAR-X. The frequent SAR observation can be used for prevention and mitigation of natural disasters including wildfires and floods. We analyzed its economic feasibility for two different cases where the proposed system is used for natural disaster prevention and mitigation in Southeast Asia. The results showed the system is feasible with the selling price of 0.6-1.5 USD/km^2.

Acknowledgements

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Budget details

Description	**Unit price**	**Qty**	**Price**
Air tickets	104,000 JPY (6,263 CNY)	2 people	208,000 JPY
Nitto	4,500 JPY	3 days x 2 people	27,000 JPY
Accommodation	8,500 JPY	2 nights x 2 people	34,000 JPY
Conference fee	13,150 JPY (149.06 AUD)	2 people	26,300 JPY
Visa fee	1,750 JPY (20 AUD)	2 people	3,500 JPY
Total			298,800 JPY

End of AY 2017 Report for SIP – Group 5

Project Title

ID: SIP17-05, Title: Disease Control for Neglected Infectious Diseases

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
14213	Yuki Usui	Frontier Sciences	Computational Biology and Medical Science	D2	Leader
15102	Mehtonen Teemu Johannes	Engineering	Department of Mechanical Engineering	D2	Leader
(Not GSDM student)	Hirotaka Fujibayashi	Frontier Sciences	Department of International Studies	M2	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

OBJECT: Japan strategy for neglected infectious diseases

Neglected tropical diseases (NTDs) are infections diseases that have not been primary target for R&D worldwide due to the market is not large enough to generate sufficient revenue and profit [1]. WHO identified 18 infectious diseases as NTDs to change this state of affairs. Government of Japan also started to promote R&D against NTDs. However, there was no method to prioritize the NTDs should be targeted from the epidemiological and science technological point of views. It is important to prioritize NTDs in order to proceed the R&D efficiently with limited fund. **Therefore, we conducted a comparative analysis of 18 NTDs from various perspectives to decide which disease(s) Japan should focus on.**

[1] Hotez, P. J., *et al*., (2007). Control of neglected tropical diseases. *New England Journal of Medicine*

Method: Explain through what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

We first conducted the scoring analysis and discussed which criteria should be prioritized for the government of Japan **(*Figure 1)**. As a result, five items was set for comparison each NTD.

1.[Population size at risk of infection from NTDs]:

The number of people at risk of infection by each NTD is obtained and compared. We will consider pathogenicity of each disease (lethal or not, curable or not, transmissible via human or not).

2.[Biological characteristics of each pathogen]:

18 NTDs includes Chagas disease, Dengue, Chikungunya, Human African trypanosomiasis and so on. These are largely divided into three pathogens (viruses, bacteria, parasites) and there is a detailed classification of pathogens. The drug development approach is different depending on pathogen characteristics. We will also classify 18 NTDs by drug development approach.

3.[Research progress level of each NTD in the world]:

Research progress is evaluated by searching the number of scientific publications. Successively, We shall assess the drug development progress of each NTD **(**Figure 2)**.

4.[Regions of prevalence of each NTD]:

18 NTDs were classified by infected region area.

5.[Strengths and weaknesses of Japan's scientific community]:

We will survey strengths and weaknesses of Japan's scientific community. For example, Japan has historically been leading in parasitology. Prof. Satoshi Omura was awarded the Nobel Prize in physiology and medicine by the development of the drug "Ivermectin" against the tropical parasites. But on the other hand, Japan has less BSL-3, 4 facilities than other developed countries.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

During the SIP activities, we obtained practical skills and leadership that are necessary to solve global issues. We have done three major activities in the project as follows below.

1. Participation of discussions with experts in UN forum

We collaborated with the United Nations Forum and hold medial session on 7th, January 2017 at Tokyo University. We discussed with panelists from government, NGO and NPO and audiences as student discussants. We obtained clear reasons why government of Japanese should solve NTDs issues and change of global views against global health issues after the Ebola outbreak in West Africa.

2. Interviews to GHIT Fund

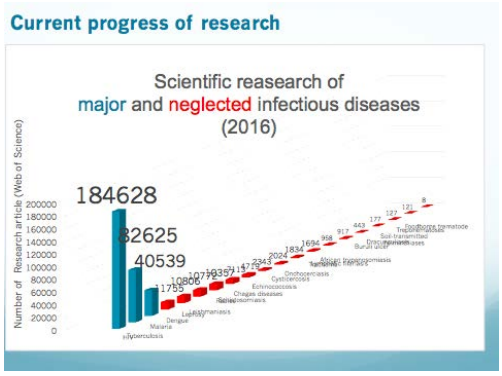
The Global Health Innovative Technology (GHIT) Fund is a unique funding organization to solve the global health issues including NTDs by collaborating with the government, private sector and civil sector. There were few collaborations opportunities with government and private sector, civil sector, and each organization tackled NTD issues independently. This fund was established in 2013 and they achieved to work global health issues by encouraging the R&D against NTDs. We interviewed with Dr. B.T. Slingsby, Mr.Sato (Vice President, External Affairs) in July 2017 **(Appendix 2)**. We presented our NTD research to Dr. B.T. Slingsby, Mr.Sato, and find the weak points of our analysis methods. Moreover, we obtained two important views to tackle NTDs issues. One point of views is that NTDs issues is not only disease problem, because non only diseases was neglected but also infected people and people at risk of infection were neglected. Second point of view is R&D NTDs is long-term investiments to developing counties, not just donation.

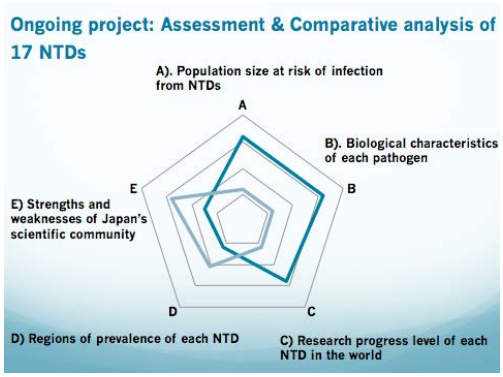
3. Holding a SIP

We hold a SIP on 22th November in 2017. In our SIP, we aimed to create a model for allocating the funding for Neglected Tropical Diseases (NTDs), including 18 diseases the World Health Organization (WHO) identified as primary targets for eradication **(Appendix 3)**. After conducting researches and a series of interviews to experts including Dr. B.T. Slingsby, CEO of the Global Health Innovative Technology (GHIT) Fund, we presented the results of our project in an IEL. In the IEL, we explained our model and research result for each of 17 NTDs, obtained comments from professionals of the field, and exchanged opinions with the GSDM students and Faculty. After IEL, we obtained the technical points needs improvements and research skills of publish health fields.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	Expense
IEL holding (inviting fee of 2 guest speakers)	13,700*2 = 27,400
Total	27,400





(* Figure1: Prioritization analysis)

(** Figure 2: Result of number of research papers of each NTD)

Appendix 1 :UN Forum, Medical sessions (17/01/07)

"Global Health Policy and Practice in Developing Countries: Challenges and Reforms—How the International Community Can Contribute to Improving Health in Developing Countries"

Appendix 2 : Interview with GHIT Fund (17/07)

(Left) Vice President, External Affairs **M. Sato**
(Center) CEO, **B.T. Slingsby**
(Right)SIP Leader, **Yuki Usui**
Photo taken by SIP **Mehtonen Teemu Johannes** At GHIT Fund Office (Tokyo)

Appendix 3: ILE (17/11/22) inviting with Prof. Toshiki Watanabe, Dr. B.T. Slingsby

End of AY 2017 Report for SIP – Group 7

Project Title

#UTokyo4SDGs

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
17-103	Karthik Varada	Engineering	Technology Management for Innovation	D2	Leader
16-202	Meihong Jia	Economics	Contemporary Economics	D1	Member
17-104	Nikhil Bugalia	Engineering	Civil Engineering	D1	Member
16-213	Pegah Hashemvand Khiabani	Engineering	Civil Engineering	D2	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

This SIP aims to increase the awareness within the university community about the United Nations Sustainable Development Goals and cultivate channels for dialogue and debate among students interested in similar issues of global development. Such dialogues are essential in forging out-of-the box thinking and partnerships among students from different disciplines. Given the multitude of problems faced by the complex world, we believe strongly of the need for such interdisciplinary learning. This will be coupled with student engagement in real-world problem solving through thematic workshops and dialogues held by experienced practitioners.

Method: Explain what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

Firstly, we created an online survey which enables students in mapping their research and personal interests to the SDG indicators. The survey employed a grading system from one to five scale and was distributed to all GSDM students and some non-GSDM students across departments. The Data thus collected helped us in identifying the focus areas for future activities.

We then hosted five Interactive Evening Lounges (IELs) that saw external practitioners and faculty members engage with students in a dialogue about diverse range of topics, all related to sustainable development and the appropriate career choices one can take up. Each of these sessions ended with students brainstorming about ways in which their research can have practical implications. An IEL dedicated to SDG based Strategy Card game needs a particular mention that it introduced the participants with constraints and challenges faced by individual agents and how individual actions accumulate towards achieving Sustainable Development Goals. Constant communication between the team and interested students through several online channels led to very high student turn out rate for every IEL.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

The survey in itself was very useful in introducing students to the concept of Sustainable Development Goals. It enabled them to identify how their research holds the potential to address not one, but several of the Goals. This learning has widened the students' scope of interest to new fields.

The Interactive Evening Lounges that were organized after that were instrumental in deepening students' interest across some of the new fields. It also helped them identifying various career pathways they can take up after graduating and how each of those routes may lead to sustainable development.

The seminar held in partnership with Prof. Nishizawa on Nov 15 saw professional management consultants with several years of corporate experience elaborate on the opportunities that require professionals to partner with experts from diverse fields thereby requiring one to constantly learn and keep abreast of new frontiers. The role of mentorship in such continuous learning was specially emphasized.

On Nov 24, we invited veteran international development practitioners to share their learnings spanning over many decades of working in developing countries. Speakers highlighted some skills that the young generation must be equipped with to solve the societal problems. One must have the skills to communicate, ability to work together in a team, and to set aside individual differences while working in unison.

Considering the survey results, we found out that numerous participants are interested in Decent Economic Growth and also Environmental Sustainability. Therefore, on Dec 6, we had a debate about how these two issues usually find themselves at odds. The role of plastic industries in leading to environmental and health related problems were discussed.

The next IEL on Jan 10 was a SDG Based strategy card game that enables students to experience how SDGs can be achieved in future. During every day conversations about sustainability, we talk in abstract terms about the need to perceive the longer-term societal implications, the need for collaboration, and the misconstrued notion of tradeoff between economic growth and environmental protection etc. This game makes these abstract conversations feel more real, and thus, motivates the player to take collective action.

The final IEL on Feb 10 was perhaps the most inspiring of all, where Founders of two technology enterprises challenging the status quo in renewable energy and space technology shared their journeys on how their research interests and hobbies led them to venture into entrepreneurship. The students were encouraged to continuously iterate various pathways to turn their research ideas into products solving real life issues. The role of finding the right team members, the need to ask for help without fear were specially emphasized.

This initiative was effective at increasing awareness of the SDGs among students in UTokyo and brought together higher education faculties, enterprises and graduate students to explore practical means to achieve SDGs. We believe that this initiative enabled students in understanding the role of technology and sciences in developing solutions that enable sustainable development. In the end, student feedbacks during IELs and other interactions indicated that the surveys and the sessions that followed have led them to widen their horizon on the practical implications of their research and academic skills.

Budget: List the budget this project implemented. *About the details, add the appendix.

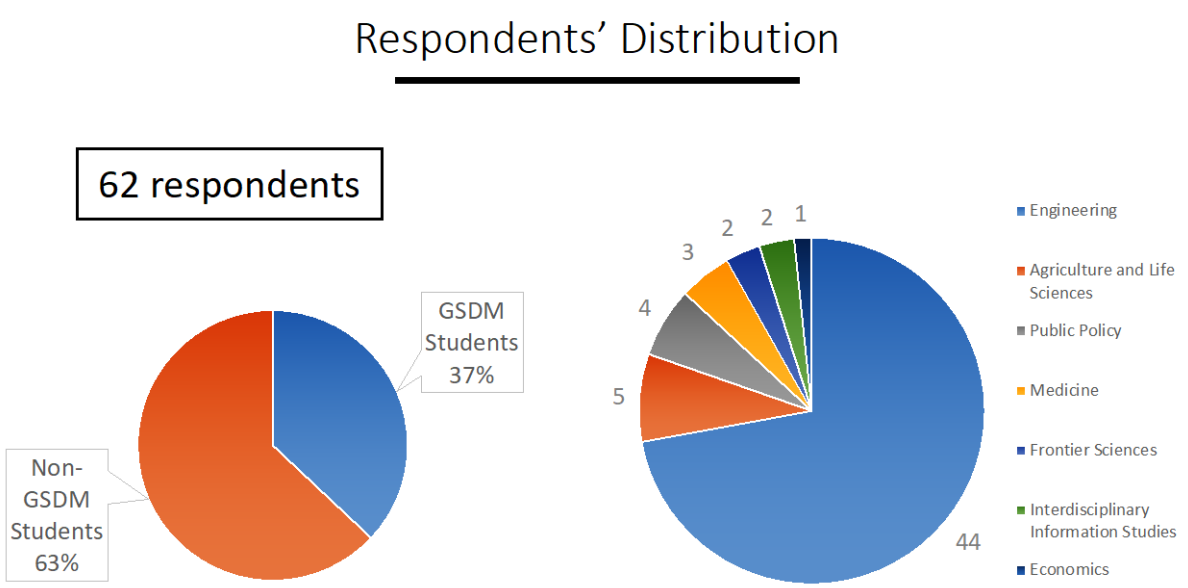
Purposes	**Expense**
Honorarium for Invited guest speakers for IELs (13,700*6=82,200)	82,200
Online Survey Platform	8978 (USD 84)
Total	91,178

Appendix (Optional)

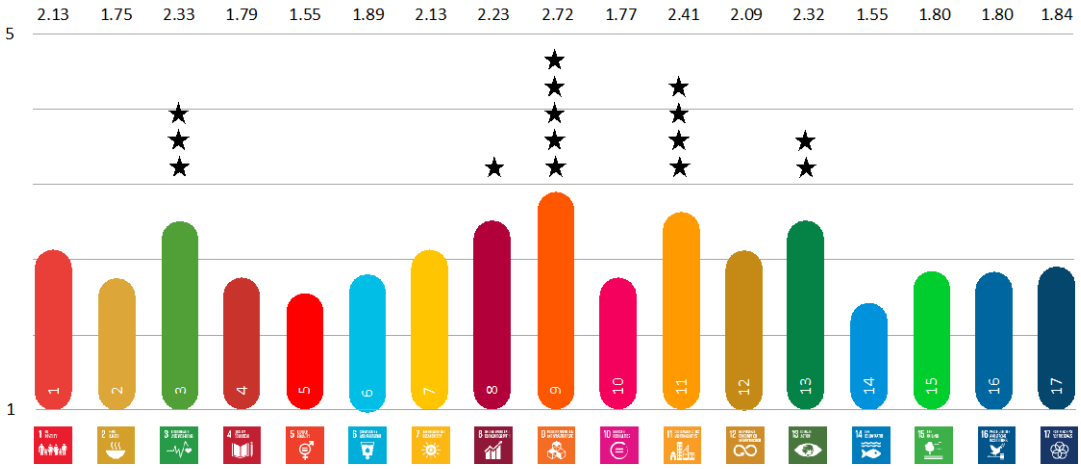
Title of IELs and the list of Speakers.

- "Sense of Good Career Choices – Global Corporations Need your Interdisciplinary Talents" Nov 15
    - Mr. Matt Brodrick, Partner, Ernst & Young
    - Ms. Chika Matsumoto, CEO, Soarria Consulting
- "Innovations to achieve Sustainable Development Goals: personal reflections from two decades" Nov 24
    - Dr. K.E. Seetharam, Asian Development Bank Institute, University of Tokyo*
    - Dr. Lakshmi Seetharam, Board of Directors, Satya Sai Education
- "Economic growth and its impact on environment and society"
    - Dr. Roberto Orsi, Lecturer, University of Tokyo
- "Experience the Future – 2013 SDGs Game" Jan 10
    - Mr. Skip Swanson, Director, WakuPro Foundation
    - SDG Card Game offered by Imacocollabo Inc.
- "Cutting Edge Technology Enterprises – Journey from Research to Entrepreneurship" Feb 05
    - Dr. Yuya Nakamura, CEO & Founder, Axelspace
    - Mr. Atsushi Shimizu, CEO & Founder, Challenergy
    - Mr. Shigeto Matsumoto, Associate, Challenergy

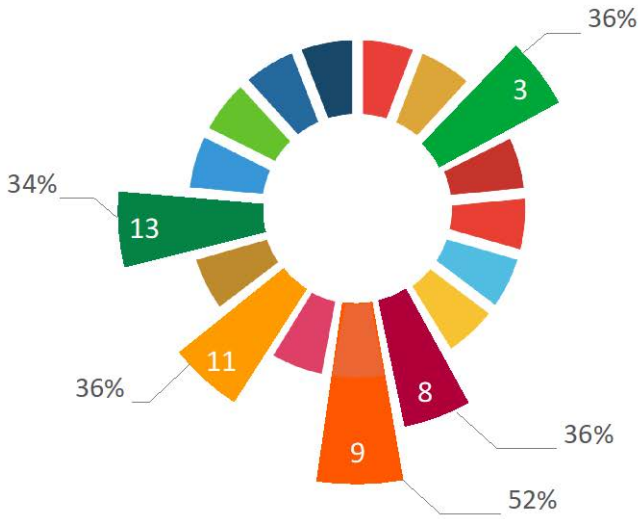
Results from the Survey



Average student rating of different goals.



Students interested in the top 5 goals.

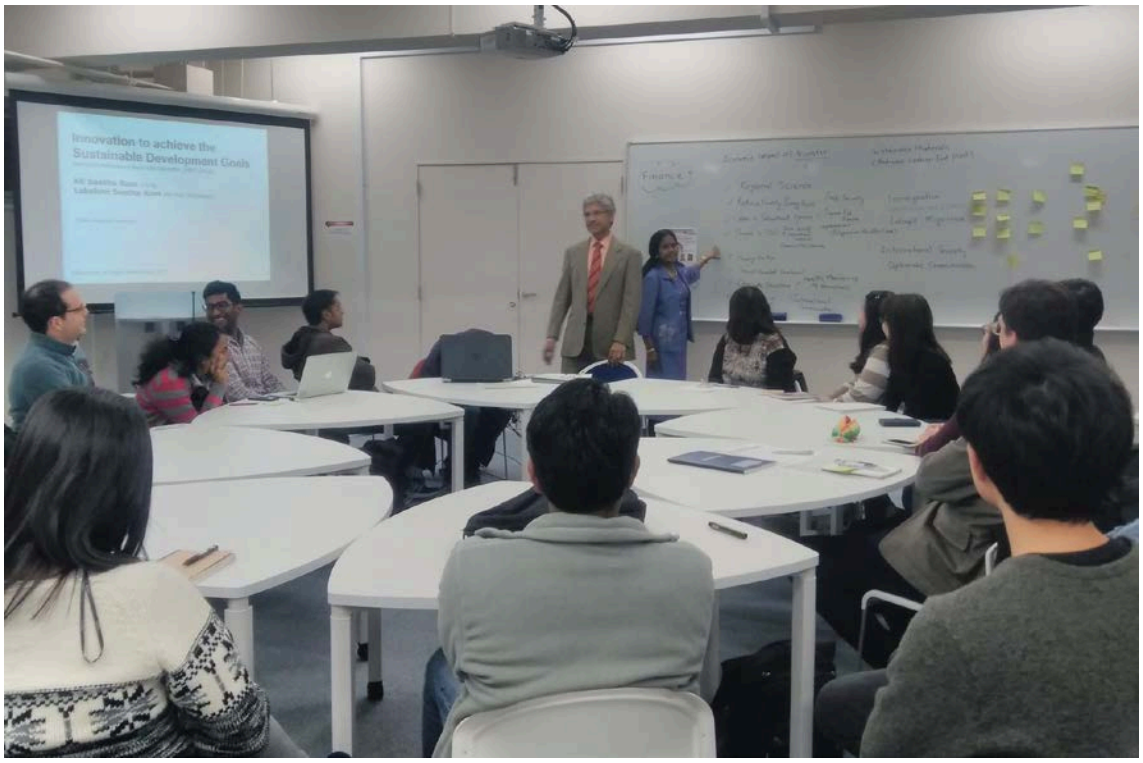


Student Initiative Project, GSDM 4

Pictures from the IELs

Role of Corporations and Career Choices

Innovations to Achieve SDGs



Economic Growth Vs Environmental Protection

SDG Card Game to experience the future


Resolve to perform what you ought.
Perform without fail what you resolve.
Confidential
Challenergy
2018/2/5
21


なっちゃん!
オレンジ

End of AY 2017 Report for SIP – Group 8

Project Title

Paradigm shift of cancer therapy

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
14106	Yuri Yoshihara	Engineering	Nuclear Engineering and Management	D2	Leader
14211	Yang Qian	Engineering	Mechanical Engineering	D2	Leader
17108	Guanxiong Wang	Frontier Science	Computational Biology and Medical Sciences	M2	Leader
14105	Seina Ohe	Frontier Science	Computational Biology and Medical Sciences	D3	Member
15116	Miarisoa Razafindrabe	Agricultural & Life Sciences	Global Agricultural Science	D1	Member
17214	Libo Wu	Engineering	Precision Engineering	D1	Member
17203	Dongig Oh	Engineering	Mechanical Engineering	D1	Member
17213	Xiaoxiao Liu	Frontier Science	Computational Biology and Medical Sciences	M2	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

This project was launched last April, in order to think about new future brought by emerging technology in medicine. In this year, this project is a pre-stage project for determining what kinds of approaches we should address to have better future.

One of the most important social issue in medical field (we call them unmet medical needs) that we thought to be satisfied is, that current cancer therapy have to kill normal cell as well as cancer cells, because it would lose people's health. And Immunotherapy has been turned out to be a technical solution to solve the social issue by removing the blocks for immune system and let them work to kill only cancer cells. However, there seems a huge gap between the current therapy and the better therapy.

The objective of this project we focused on is to draw some possible futures as scenarios, which would help us to understand what kinds of approaches we should take to have better future.

Method: Explain through what kind of approaches you tried to achieve the objective.

Presumptions (Limitations) of this scenario planning work

In general scenario-planning process, we need to gather experts in multi fields and make an expert group to discuss issues of each field correctly. As thinking the topic focused on in our project, in order to make the most reliable scenarios, we think the expert group should consist of some experts and medical doctors working on revision of clinical practice guidelines, researchers, and politicians who are making policies for drug price or studying the cutting edge of cancer immunotherapy, and work on revision of clinical practice guidelines, under consideration of COI (Conflict of Interest), and an artist of scenario planning organize the scenario planning process. However, in order to complete this scenario planning with the minimum resources we have, we behaved experts in each field, and listed-up/ranked issues related to future of cancer therapy, and think some scenarios. Besides, in order to make the scenarios we made more reliable, we obtained some experts opinions by some interview.

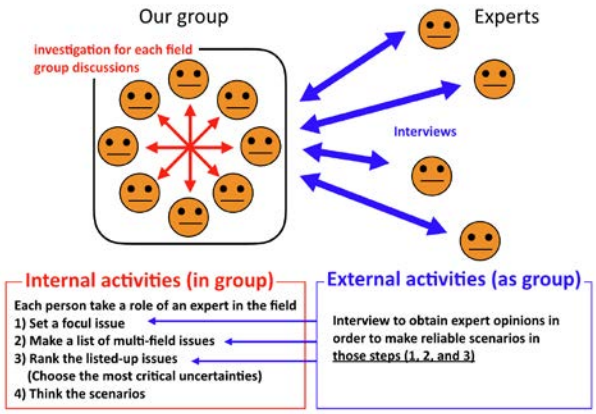


Figure 1: Internal/External project activity for scenario planning

Approach overview

First of all, we conducted several interviews with experts from medical field to set the goal of SIP project and concrete our ideas. It helped us to understand current issues of cancer cell therapy and gave us hint to how to approach to find our target. After interviews, we organized scenario planning, a structured way for organizations to think about the future, to focus on urgent issues in cancer cell therapy field. To be specific, we categorized all the issues using two axis; certainty and criticality. Further interview with expert of scenario planning and energy policy are planned to verify our current works and ask some advices.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

Though several interviews we conducted in this project, we could clarify our scenarios by determining the acceleration of clinical practice guideline and clinical infrastructure for early detection were the most critical and uncertain. However, through additional interviews after final report, we also realized there are some faults in this scenario planning process.

1) We missed a viewpoint to think about the issues. If the viewpoint was set, the issues would different. We should be able to find different scenarios.

2) We skipped to get a consensus to explain the current situation with the audience. We could think about issues of immunotherapy from patients' viewpoint, and we should have obtained their opinions by opening workshop or interviewing at the first stage of scenario planning.

Because of some missing steps in our scenario planning process, the scenario we made was slightly far from perfect one, and we haven't discussed well what kinds of concrete approaches necessary to lead better future, we could achieve to think the future of immunotherapy by scenario planning in this project.

Budget: List the budget this project implemented. (See more details in **Appendix-2**.)

Purposes	**Expense**
Total	0 yen

[Appendix-1] Details of Interviews

#Interview-1: Prof.Lee

Prof. Jung Su Lee (The University of Tokyo, Public Health)	
DATE: July 10 2017	PLACE: Medical Faculty Bldg-3 Annex, Hongo

Purpose for this interview:
Because of the lackness of our fundamental knowledge about cancer therapy, we interviewed Prof.Lee In order to understand what are important keywords and knowledge we have to know at the beginning of starting this project.

Interview summary:
We have to understand what is the standard therapy in the country. Every treatment has side effect, and works for some patients, but not for others. Besides, she suggested us that some political issues affect the cancer therapy, such as health insurance. In the newly developed therapy for some cancer, it can be always controversial issue. For example, there is a discussion of trade-offs including, 'clinical trial vs standard therapy', and 'effectiveness and safety'. Generally, It takes long time for newly developed therapy to be standard therapy because the necessity of enough amount of evidence that prove the treatment is the most suitable than other treatments. Doctor basically suggested some options of treatment to patients according to clinical practice guideline. Evidence-based medicine can be a keyword to think what kinds of treatment can be chosen by doctors and patients.

Conclusion:
We learned through talking with Prof.Lee about that doctor and patients determine therapy according to clinical practice guideline, and it generally takes much time for that new medical treatment will be standard therapy because necessity of enough amount of clinical evidence to judge it is the most suitable treatment than other treatments.

#Interview-2: Prof.Kano

Prof. Shingo Kano (The University of Tokyo, Bio-innovation Policy)	
DATE: July 2st, 2017	PLACE: Shirogane 2nd Building, Shirogane-dai

Purpose for this interview:
In order to discuss about immunotherapy and methodology to think about future, we interviewed Prof.Kano in order to understand what we should do for scenario planning.

Interview summary:
Before the meeting, he suggested us some of books and websites about immunotherapy. We talked about what is immunotherapy and why people say immunotherapy bring new paradigm in cancer therapy from viewpoint of a scientist. Scenario is a story of future estimated to happen in future under some assumptions. If we just focus on the things that seem to happen probably, we can just see a kind of usual future that will happen with probably with the no change. In order to bring better future, we have to think about the most critical and the most uncertain things, and what kinds of approaches are necessary for make the better future happen.

Conclusion:
We could make sure that immunotherapy has changed cancer therapy, and scenario planning can be used for us to think about future brought by immunotherapy, which would indicated us what kinds of approaches are effective to bring better future.

#3 Interview-3: Prof.Kato

Prof.Naoya Kato (Chiba University, Gastroenterology)	
DATE: November 2nd, 2017	PLACE: Chiba Univ. School of Medicine Entrance, Chiba

Purpose for this interview:
The motivation of this visit to Prof.Kato was to discuss with Prof.Kato the effectiveness of interviewing patients in hospital of Chiba University and to consult him about what kinds of approaches are more suitable for our project.

Interview summary:
We discussed the necessity for focusing on specific topics or aspects for cancer therapy, and how to find good topics we can address. One of the most effective ways he suggested us was to focusing on a keyword “unmet medical needs”, which is not solved but demanded in science, society, and patients. He said we could investigate unmet medical needs by ourselves through interviews to experts. Besides, he talked about his opinions for cancer therapy from the viewpoint of a scientist and hospital doctor. Here is the talk of his interested points.

- New cancer-therapy technologies ... molecular targeted medicine, especially in immunotherapy
- Social issues: Increase of developing cost of drug & insurance fee
- Interesting points from viewpoint of scientist: Bio-marker, precision medicine, AI, terminal care
- Usefulness of early-detection of cancer therapy -- Lead-time bias
- Therapy options: drug resistance, combination of drug
- Who makes “clinical practical guideline”? -- WHO, societies, Hospitals..
- Which treatment has priority than others? Response rate (SD, PR, CR, PD)

Conclusion:
We could obtain valuable hints to find the issues we should address though this interview. Especially we could recognize a good keyword of “unmet medical needs” as things we want to make sure though our project.

#4 Interview-4: Prof.Kakuwa

Prof. Masahiro Kakuwa (The University of Tokyo, Graduate School of Public Policy)	
DATE: February 27th, 2018	PLACE: International Academic Research Bldg., Hongo

Purpose for this interview:
Through receiving feedbacks about our presentation in the SIP final report on Feb.7th, we realized the necessity of more effort for explaining our project. The method we took to achieve this project goal, "scenario planning", is one of the powerful techniques for helping policy examination. To improve this explanation, we conducted an additional interview to an expert of scenario planning and energy policy, Prof. Kakuwa.

Interview summary:
He said there are many different approaches and models for scenario planning, depending on 'who want to achieve what' by scenario planning. He proposed to us one of the approaches for scenario planning, which is suitable for such an open topic, and an educational activity like student group work as following:
1) Firstly, in order to explain the scenarios we made, we should be able to get consensus with most of all audiences about the balance of issues for immunotherapy in the current situation. In our case, we can set a viewpoint of general people (because half of people would die of cancer) and get opinions from general people by opening a workshop about what/how they think about immunotherapy as a first step.
2) Secondly, we can think what is the most significant issue that should be changed into leading better story for the person. And clarify the path to get the better scenario if you change the most significant issue.
3) Thirdly, to think what kinds of drivers necessary to change the significant issue? You might be able to find some drivers and can make a map for the drivers according to certainty and criticality. Then you can find the most uncertain and critical issues in the map, and make scenarios.
He gave some encouraging comments to us as like 'The process of our scenario planning is not matured, but this challenge is interesting. If we will continue this project next academic year, he can help us. Also he suggested us the possibility to collaborate with STGI to work with scenario planning.

Conclusion:
We could learn the better approach for us to address scenario planning, and it would be better for not only to audience who listen to our explanation, but also better for us in terms of working as SIP, we can interact with many people and experts in actual stakeholders. We couldn't do very well as group work in this year, but hope we could work better in next academic year, and hopefully introducing our working to society and have a open discussion in future.

#5 Interview-5: Prof.Kamae

Prof. Isao Kamae (The University of Tokyo, Health Technology Assessment and Public Policy)	
DATE: February 28th, 2018	PLACE: International Academic Research Bldg., Hongo

Purpose for this interview:
In order to ask expert's opinions about how to determine new medical technology such as immunotherapy, we interviewed to Prof.Kamae, who is an expert of Health Technology Assessment (HTA).

Interview summary:
He suggested us firstly to clarify the viewpoint if we talk about any issues. Especially about medicine, if you

set viewpoints of different persons, you might see things differently. Secondary, the cutting edge of the issue is also important. It would be much better to focus on the specific cutting edge of a specific case as a first stage of the project. You can discuss deeper things from the specific cutting edge of the issue, but not from the general cutting edge of the vague issue.
Also he talked about different viewpoints in medical field. Not only general difference between patients, doctors, but also suggested us about different viewpoints between hospital doctors and practitioners, attending doctors and professional doctors, general doctors and hospital directors, etc.
Also he suggested us if we think immunotherapy from the viewpoint of patients, decision making for treatment is also in our field of view. In the current situation, the decision-making for treatment is happened between patient and government. There are information that help patients with understanding which therapy is suitable for themselves. Patients can decline doctors' suggestions, and choose other options, but your options are limited by if the treatment is insured, etc. About the future of drug for immunotherapy, we talked about the case of the cost 'Opdibo'. He talked there is no person who knows how it will be in future and how it should be from the viewpoint of a scientist, but indicated the possibility of decrease of the drug cost in future under the current law. The cost of drug should be determined through reasonable processes, and if the procedures are correct, we should be able to get a consensus for it if no one knows how much the drug should be.

Conclusion:
We could obtain good advice from Prof.Kamae not only about how we should approach the issues in general, but also some suggestions about the drug cost for emerging drugs. Through discussion with him, we could learn the big background that has been driving the decrease of price of Obdibo.

#6 Interview-6: Prof.Sugano

Prof. Sumio Sugano (The University of Tokyo, Medical Genome Science)	
DATE: March 20th 2018	PLACE: Ito International Research Center, Hongo

Purpose for this interview:
In a public relation brochure "創成" published by , he talked about three breakthrough technologies including immunotherapy, and he said they would bring different cancer therapy in near future. In order to ask about his article and discuss what kinds of technological & social package is necessary for the future, we will interview Prof.Sugano in March. (after submission of this final report).

Interview summary:
Not yet

Conclusion:
Not yet

[Appendix-2] Budget Implementation

1) Initial budget planned in May

Purposes & Justification	Estimated expense (yen)
Interview/fieldwork (Only transportation fee) (The interview place is supposed to be Kanto Area) - The number of interview (planned): 4-5 times - The number of interviewers / interview: 2 persons - The maximum transportation fee / interviewer: 1,000 yen	8,000 - 10,000 1,000 x 2 for 4 - 5 interviews => 8,000 - 10,000
Seminar/IEL organization (Support of transportation fee to invited speakers) (The interview place is supposed to be Kanto Area) - The number of invited speakers: 2-3 - The maximum transportation fee / interviewer: 1,000 yen	2,000 - 3,000 1,000 x 2 - 3 speakers => 2,000 - 3,000
Total	10,000 - 13,000

2) Changed budget plan submitted in November

(a) Purposes & items		(b) Approved	(c) Already spent	(d) Will be spent	(e) =(b)-(c)-(d)
[1]Approved	Meet & talk with external experts (2 persons/interview)	10,000	0	19,746	-9,746
	IEL organization (invite 2-3 speakers) Support of transportation fee to speakers	3,000	0	0	+3,000
Total					-6,746

(b) Approved: the budget SIP committee approved for your group
(c) Already spent: the budget your group has already spent
(d) Will be spent: the budget your group plans to spend in AY2016 (but not spent yet)
(e) if it is negative, it means that you need additional budget.

Justification for additional budget (if the total of (e) is negative)

Reasons for necessity of additional budget

When we started this SIP, we were planning to go to interview to the hospital doctors in ISMUT hospital (東京大学医科学研究所付属病院), but a hospital doctor, whom we could successfully contact in October, has just moved to Chiba University in April 2017. Therefore, some additional budget is necessary for transportation fee from Hongo campus to Chiba University. Though we can compensate some of the additional budget for interview, from the budget for organizing an IEL, we still need 6,746 yen as an additional budget.

Details:

i) Transportation fee (one way): 1,097 yen

- Train: Todai-mae →Iidabashi → JR Chiba : 877 yen
- Bus: JR Chiba → Chiba Univ.,School of Medicine Entrance: 220 yen

ii) Interview schedule:

➢ First interview (pre-interview to Dr. Kato):
1,097 yen x 2 (round) x 3 (persons) = 6,582 yen

➢ Second interview (to patients (アンケート配布) & hospital doctors):
1,097 yen x 2 (round) x 3 (persons) = 6,582 yen

➢ Third interview (to patients (アンケート回収) & hospital doctors):
1,097 yen x 2 (round) x 3 (persons) = 6,582 yen

Total: 6,582 + 6,582 + 6,582 = 19,746 yen → **(e)**: 13,000 – 19,746 = - 6,746 yen

3) Final implementation by end of February

The left Budget: 19,746 - 0 = 19,746 yen

Excuse of change of budget implementation

Because of the difficulty for the most of leaders & members to go to interview, we changed the schedule to go to interview to another experts instead of patients in the hospitals. Besides, some additional interviews were conducted mainly in Hongo campus, and thus, it didn't need any budget except for the interview to Dr.Kato on November 2nd.

End of AY 2017 Report for SIP – Group 11

Project Title

Food waste in Japan

Team

GSDM ID	Name	School	Department	Year (e.g. D1)	Leader/ member
17112	Akter Rumana	Global Agricultural & Life Sciences	Global Agricultural Sciences	D1	Leader
15116	Razafindrabe Miarisoa	Global Agricultural & Life Sciences	Global Agricultural Sciences	D1	Leader
	Nakamura Yuichi	Information Science and Technology	Institute of Industrial Science	M1	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

According to the FAO, food waste is a part of food loss and refers to discarding or alternative (non-food) use of food that is safe and nutritious for human consumption along the entire food supply chain. Although millions of people around the world are struggling to find enough food to eat, surprisingly millions of tons of food is tossed out every year. Between 33-50% of all food produced globally is never eaten. Food waste is a huge problem mostly in developed countries and it has serious economic and environmental consequences. Food waste is a critical issue in Japan especially in light with the country's low food self-sufficiency rate and shortage of available landfill sites for waste disposal.

Why the issue is important

800 million people go to bed hungry every night, therefore morally this is not right to waste food. The food waste from retailers and consumers in developed countries is more than enough to feed the world's 870 food insecure people. Food waste is very bad for the environment too. Many resources like land, water, labor, and energy are utilized to grow those uneaten foods. In addition, when these food wastes go to landfill, releasing so much greenhouse gases by creating methane. Therefore, due to moral, economic and environmental reasons, we have to consider this issue seriously.

Method: Explain through what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

We have decided first to understand the food waste issue in Japan from the stakeholders like farmer, whole seller, retailer and consumer point of view and then to come up with possible recommendation to take appropriate steps in reducing food waste and loss in Japan. To do that we have developed a semi-structured qualitative questionnaire to interview relevant stakeholders of each level to understand factors affecting each stakeholder while producing, selling and buying food items through directly interviewing them. In our project, food means fresh and frozen fish, vegetables, fruits, and meat. So far data was collected from 5 consumers and 1 whole seller. Agencies such as the Japan Agriculture (JA) is planned to be approached as well. Interview will be also conducted with food waste specialists.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

It is expected that the results of this project would allow us to understand the reasons of why the wholesaler or retailers are not willing to buy/sell certain kind of agriculture/aquaculture products that is produced at firm level and how much food they waste each day (if there is any). What are the consumers preferences while buying mentioned food item would also be explained by the study results.

In January, 2018, we had conducted few interviews with 5 consumers around a supermarket in Nezu area. We have also interviewed 1 retailers of that supermarket. Results show that 4 out of 5 persons came to the supermarket to buy vegetables and 2 of them also bought fruits. While buying these food items, all of them replied that they consider the size of the products and 2 of them mentioned freshness as well. Only one person mentioned about price and one person thinks about the color. Interestingly, all of them said that they are able to finish everything what they buy and they do not through anything away. Furthermore, all of them mentioned that they buy food from the supermarket to get the cheaper price. When the respondents were asked how to decide how much food to buy each time, most of them replied that they consider the quantity of buying based on their need or shortage amount they have. Only 1 person said she buys the quantity of food considering the price. The respondents affirmed to consume all their foods.
According to the retailer/supermarket staff, they buy fruits and vegetables directly from the market. They know what consumers are looking for especially the size, color, shape and price of goods. In case of perished and non-sold food item, the supermarket usually lowers the price by only removing the perished food from the package.

We started the project quite lately, therefore, did not have opportunity to interview all the relevant stakeholders. We plan to interview other stakeholders as planned if the project is extended for the second year.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense**
Total	0

Appendix 1. Questionnaire for interviews

Date: ……/…../…. Area:

Respondent: farmer/super market/whole seller/retailer/consumer

Farmer

1. What is the per year production (…… KG)
2. What is the per month production (…….. kg)
3. How much do you sale per month (quantity)
4. How much do you sale per year (quantity)
5. Where do you sale agricultural products: a) whole seller b) Retailer c) Local market d) neighbor e) other
6. Where do you prefer to sell produces: a) whole seller b) Retailer c) Locally d) Other
7. Why selling to whole seller/retailer: a) profitable b) easy to sell bulk amount c) others
8. Why do you sell to local market: a) not good quality b) produced small quantity c) others
9. If farmer is selling produces within neighborhood, then ask why: a) not good quality b) produced small quantity c) easy to sell d) others…
10. If you do not sell all the harvest, why not: a) not good size b) not good shape c) Not good color d) buyers do not like it e) Others
11. Do you sometimes/always have any unsold harvest: a) vegetables b) fruits c) fish: a) yes b) no
12. What do you do with them: a) through away b) give it to someone c) sell locally at cheaper price
13. Do you have to through some of the produces due to not being good quality: a) yes b) no
14. Do you through some of the produces if there is over production: a) yes b) no
15. If yes, why a) to keep market price stable b) can't sell them c) others
16. Who are your main buyers: a) whole seller b) Retailer c) Local market d) neighbor e) other
17. What things they prefer to buy: a) good quality b) bad quality c) price d) others

Whole seller/retailer

1. Where do you buy vegetables from: a) directly from farmer b) association
2. Where do you buy fruits from: a) directly from farmer b) association
3. Where do you buy rice from: a) directly from farmer b) association
4. What things you consider while buying vegetables: a) size b) color c) shape d) season e) price f) freshness
5. What things you consider while buying fruits: a) size b) color c) shape d) season e) price f) freshness
6. What things you consider while buying fish: a) size b) season c) perishability d) condition of fish
7. Why do you think about those conditions: a) customer care about b) we care about c) others
8. What percent of what you sell daily become wasted: a) vegetable……. b) fruits…….. c) fish……..
9. What do you do with perished and non-sold food: a) sell in discounted price b) through away c) sell to restaurants d) others

Consumer:

1. What fresh food you bought today: a) vegetables b) fruits c) fish
2. What things you consider while buying these: a) size b) color c) shape d) season e) price f) freshness
3. Are you able to eat/finish all the food you buy: a) yes b) no c) not always
4. What do you do if you are not able to eat them: a) through away b) others
5. Do you prefer to buy food from: a) super market b) local food shop c) convenient shop d) others
6. Why you do so: a) good quality b) cheaper price d) near to my house e) others
7. How do they decide the amount of food that they buy at a supermarket
8. What do they feel when they find there is an excessive amount of food in their fridge because they have bought too much.
9. What would they do if there is an excessive amount of food? Just throw away or not?

End of AY 2017 Report for SIP – Group 12

Project ID & Title

SIP17-12: Self-Powered Sensor Device for the Elderly

Team

GSDM ID	Name	School	Department	Year	Leader/ Member
16102	SU Meng (CN)	Engineering	Precision Engineering	D1	Leader
16212	HARTWIG Lisa (USA)	Medicine	Community & Global Health	D1	Leader
17212	XU Yang (CN)	Frontier Sciences	Computational Biology & Medical Sciences	D1	Member
17209	WANG Guantong (CN)	Engineering	Mechanical Engineering	D1	Member
17210	GO Yui (JPN)	Frontier Sciences	Computational Biology & Medical Sciences	M1	Member

Objective: Explain what social/global issues that this project tried to address and why the issue is important.

Japan is one of the most rapidly aging societies in the world, with the rest of the world to follow as demographic decline progresses in predominantly developed countries. Japanese society has yet to grapple its greatest problem: how to adequately take care of its ballooning elderly population, which is estimated to comprise 40% of the population by 2040, up from the current 26%. With high demands on younger people at work and the current caretaking provider system that provides for the elderly, the traditional family structure of caretaking has broken down in Japan in recent decades. This means that elderly family members are more likely to live alone than ever before.

The most recent census of Japan (2015) estimates that approximately 6 million elderly live alone in Japan. This would be our target market as opposed to elderly in general. An elderly person living alone without consistent supervision needs a way to alert caretakers or medical personnel if there is a problem. Additionally, there is also a rising precedent for elderly people that have no caretakers and are unable to alert about their passing to anyone.

Thus, our SIP attempted to combat this problem by designing a simple device that can function as an alarm/notification system even if, say, the deceased tenant has no electricity due to ceasing payment of electricity bills. Our device is unique in that it was created with extremely low-cost materials and advanced technology to combat higher-maintenance systems currently in place. We designed and prototyped a self-powered sensor device that can alert families and/or medical personnel about aged people in need.

Method: Explain through what kind of approaches you tried to achieve the objective.

*About the list and details of the interview, add the appendix.

We developed a self-powered sensor system to monitor the movement of the elderly for the purpose of alerting caretakers and medical personnel of any inactivity or trouble. This device and system was low-cost and easy to use in order to allow for accessibility while also respecting privacy concerns.

As a group we discussed how to design the prototype and determined to take two approaches: testing a thin layer of piezoelectric or triboelectric film on the floor or bed and a thermoelectric device approach. Meanwhile, the other half of the group would identify stakeholders and key informants about the social issue and aging society to determine a better prototype design.

The energy-harvesting film could generate electrical signals according to the elder's motions or movement, by which people can learn the activity range of the elderly with collected signals. Thus, if there was no signal, the self-powered system could alert a network of caretaking individuals immediately. The thermoelectric device can collect signals from elderly living alone efficiently by converting heat energy to electricity. These devices can collect signal changes produced by different body temperatures and movements. Thus, it would be easy to find if something happened to elderly living alone, especially in the case of death or high fever. Both devices tested successfully in this prototype stage as shown in the Appendix photos and diagrams.

Five interviews were conducted with stakeholders and experts in aging, community health workers,

government officials, and the private sector. Questions were prepared and target and business research was done in advance to facilitate the interviews and report development. Furthermore, by incorporating feedback from the stakeholder interviews throughout the project, we were able to change the design from an initial small array into considering it to have a floor covering or waterproof/ wearable conception in the shower. Alternatively, connecting the system to a building rather than within the same household, etc.

Outcome: Explain what kind of results you obtained from this project and discuss how it addressed your focal social/global issues.

We had two expected deliverables: (1) an initial prototype of a self-powered sensor system, and (2) a business plan including policy recommendations for designing the prototype once proven successful through our testing processes. The prototype incorporates advanced energy harvesting technologies in order to solve a pressing social problem.

Our vision for this project included an initial prototype and business plan with policy recommendations as producing a full product is out of the scope of our capabilities. We discovered how to produce something like the idea of an "MVP" (Minimum Viable Product) in the start-up world, which is to test early stages in the market and provide feedback for future product development. Therefore, we consider our SIP as successful because we could demonstrate the testing of a prototype alongside a business plan/report with policy recommendations within 6 months. These results addressed our focal social issue by coming up with a prototype that interested both stakeholders and our audience of external practitioners.

This addresses our proposed social issue of taking care of a large elderly population in Japan, but also by extension the world, as many countries are also following an aging pattern as fertility decline progresses worldwide. We targeted the smaller market of Japan to create a business plan and policy recommendations alongside a prototype model. Our report could help other high-level stakeholders understand their issue.

By combining each student's background and seeking out feedback from expert practitioners and if possible, external stakeholders, we created a prototype and recommendations that can effectively solve this problem for some Japanese elderly and the greater Japanese society. While we consider this SIP complete, we would be open to passing on leadership and continuance to other GSDM students for further developing the prototype and meeting additional market testers or stakeholders.

Budget: List the budget this project implemented. *About the details, add the appendix.

Purposes	**Expense**
Self-powered system's raw material	
Triboelectric energy harvester	46,848 JPY
Thermoelectric energy harvester	16,449 JPY
Electronic parts **(Signal conversion, signal adjustment, circuit assembly)**	57,387 JPY
Travel expenses to visit and interview stakeholders	
Round Trip train ticket for 2 people = (3300JPY x 1) + (1380JPY x1)	4,680 JPY
Total	**125,364 JPY**
(ORIGINALLY REQUESTED BUDGET)	**(174,254JPY)**

Appendix

1. Final Business Report with Policy Recommendations (Pg.3)
2. List of potential questions for interviews depending on sector (Pg. 10)
3. Email templates in both English and Japanese for reaching out to stakeholders and key informants (Pg. 12)
4. Interview Transcripts (Pg. 13)
    a) Kyo Takahashi, Aging Expert at Institute of Gerontology (aging) (Pg. 13)
    b) Social Worker for the Elderly (aging care) (Pg. 14)
    c) Tatsuya Honda, Young, innovative Forbes "30 under 30" researcher at Fujitsu (start-up) (Pg. 15)
    d) Yuji Yamamoto, CEO of Healthcare Data Management company Minacare (private sector, data) (Pg.17)
    e) Tomihara Sayaka, Deputy Director, METI Healthcare Industries Division (government) (Pg. 19)

Business Plan with Policy Recommendations for Prototype of "Self-Powered Sensor Device for the Elderly"

Produced by Student Initiative Project (SIP) Group 12

GSDM Program, University of Tokyo

(**Lisa Hartwig, Meng Su,** Yui Go, Guantong Wang, Yang Xu)

Executive Summary

Japan's aging society has created a need for innovative ideas to overcome challenges in caretaking and providing services for those over the age of 65 years old. As more elderly people live alone in isolation, there is a need for products to alert caretakers when there is possible injury or early passing. Currently, there are sensor devices and services on the market, but they are high-cost and often require some form of usage or management by the elderly person in question. Our prototype seeks to fill this gap by providing a low-cost alarm sensor device using novel technology that requires no electricity or management once installed.

Thus, our multidisciplinary team of University of Tokyo students in engineering, global health, and frontier sciences designed an innovative prototype for a device that can function as a self-powered alarm/notification system for elderly people living alone. Our device is unique in that it was created with extremely low-cost materials and advanced technology to combat higher-maintenance systems currently in place. We designed and prototyped a self-powered sensor device that can alert families and/or medical personnel about aged people in need.

Background

Japan is one of the most rapidly aging societies in the world, with the rest of the world to follow as demographic decline progresses in predominantly developed countries. Japanese society has yet to grapple its greatest problem: how to adequately take care of its ballooning elderly population, which is estimated to comprise 40% of the population by 2040, up from the current 26%. With high demands on younger people at work and the current caretaking provider system that provides for the elderly, the traditional family structure of caretaking has broken down in Japan in recent decades. This means that elderly family members are more likely to live alone than ever before.

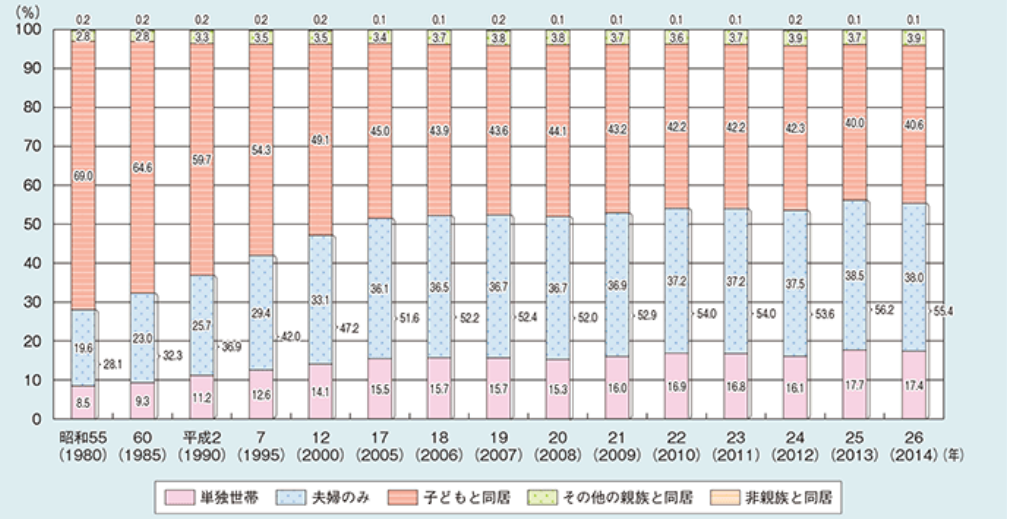
The most recent census of Japan (2015) estimates that approximately 6 million elderly live alone in Japan. This would be our target market as opposed to elderly in general. An elderly person living alone without consistent supervision needs a way to alert caretakers or medical personnel if there is a problem. Additionally, there is also a rising precedent for elderly people that have no caretakers and are unable to alert about their passing to anyone.

Target Market

After researching the situation of the elderly people living in Japan, we determined that our final user would be an elderly person living alone and their caretakers. First of all, the number of elderly people not living with their children is clearly increasing in current years if we look at the below chart (Cabinet Office of Japan, 2016). The orange color shows the decrease over time from 70% in 1980 to 40% today for those who live with their children. The pink and blue colors show an increase in living alone or only with a partner, respectively.

The division of families that include 65 years or older family members

図1－2－1－2　家族形態別にみた65歳以上の高齢者の割合

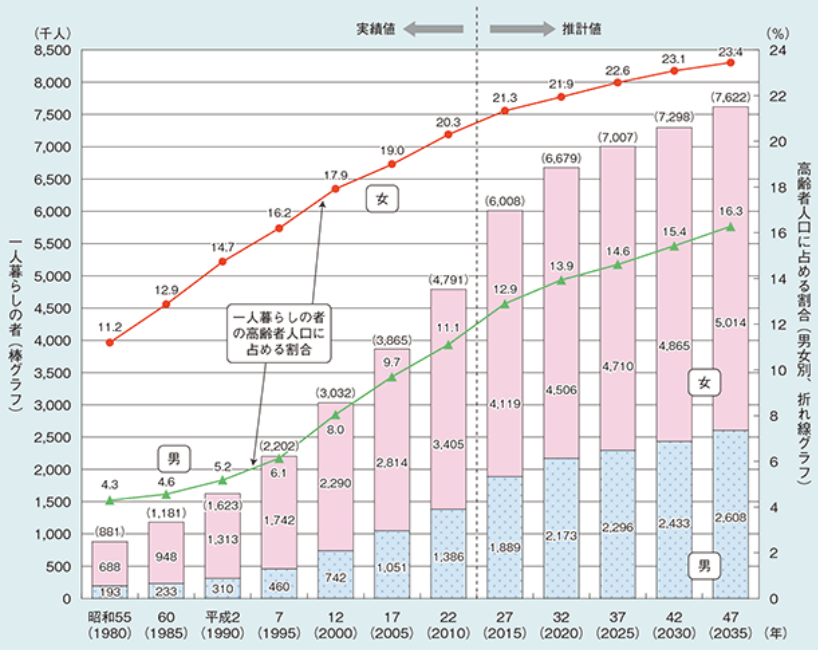


資料：昭和60年以前は厚生省「厚生行政基礎調査」、昭和61年以降は厚生労働省「国民生活基礎調査」
（注）平成7年の数値は兵庫県を除いたもの、平成23年の数値は岩手県、宮城県及び福島県を除いたもの、平成24年の数値は福島県を除いたものである。

If we consider the growth and change of elderly people living alone, there is a strong projection for growth in this target group in the coming years. The below chart from the Cabinet Office of Japan (2016) indicates the current growth projections through 2035. Both men (blue) and women's (pink) growth is increasing significantly in projections, with a higher proportion for females due to the life expectancy of women being longer than men.

Movement in Elderly People Living Alone

図1－2－1－3　一人暮らし高齢者の動向



資料：平成22年までは総務省「国勢調査」、平成27年以降は国立社会保障・人口問題研究所「日本の世帯数の将来推計（平成25（2013）年1月推計）」、「日本の将来推計人口（平成24（2012）年1月推計）」
（注1）「一人暮らし」とは、上記の調査・推計における「単独世帯」のことを指す。
（注2）棒グラフ上の（　）内は65歳以上の一人暮らし高齢者の男女計
（注3）四捨五入のため合計は必ずしも一致しない。

Thus, the above charts show that there is and will be a significant outlook for this target segment and a greater need for caretaking services.

Competitive Analysis: Public Sector

At this time, there are different initiatives for the public sector in providing services for elderly people. For example, there are “minseiiin” who provide consultation and support for elderly people’s welfare in a given caretaking area.

Finally, a volunteer welfare committee through local civil servants commissioned by the Ministry of Health, Labour and Welfare also provides support. However, because the activities are provided on a volunteer basis, there is a shortage and high demand. Those who meet the requirements of working more than three years with high enthusiasm and specific knowledge of welfare and circumstances of the area can qualify.

Social welfare councils work in cooperation with commerce members of citizens to check the households with only elderly people in the area, in particular the bedridden elderly. They check the security situation and confirm safety during disasters. The “regional comprehensive support center” includes specialized staff members for providing nursing care and welfare. There is a need for connecting the centers and residents, which our device could provide if we cooperated with the public sector.

Competitive Analysis: Private Sector

A competitor’s analysis was done on other existing products in the market and summarized by the table below.

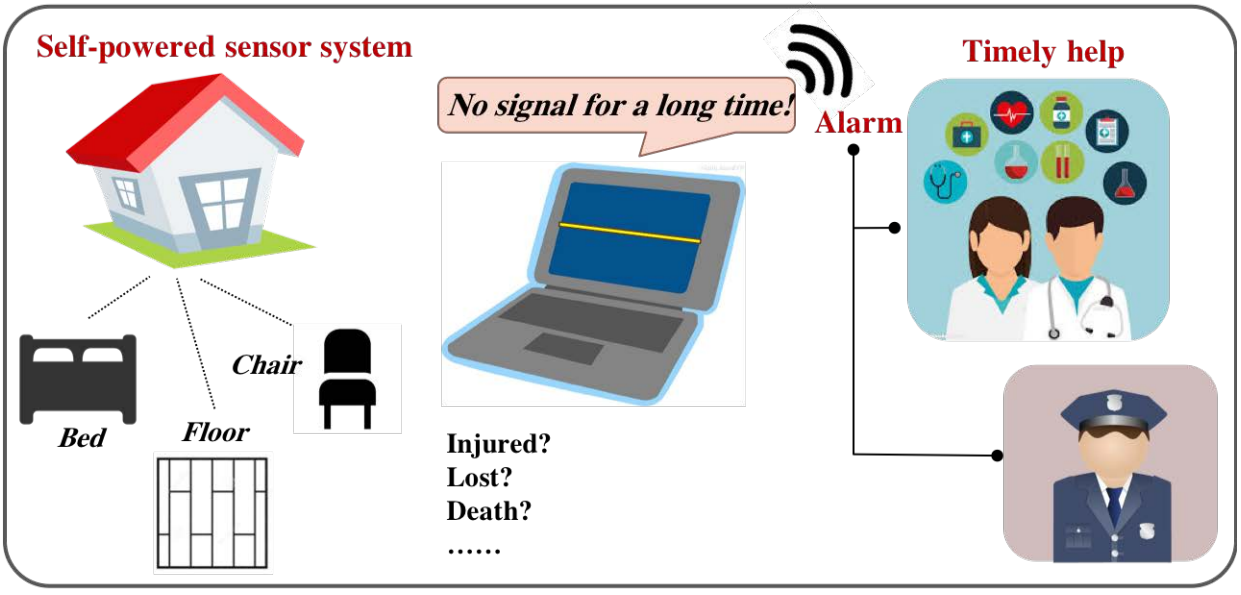
Who to alarm	Company Category	Company name	Device	Price
Security workers	Security	SECOM	Portable Alarm	\4,700/month
			sensor	
			medical watch	option＋\900/month
		ALSOK	controller	device \47,200
			door motion sensor	construction \15,800
				\2,000/month
Family member	Home electric appliances	Panasonic	Camera	¥20,740
			infrared sensor	¥4,320
			regulation device	¥12,960
	Internet service	iTSCOM	IP camera	\3,380/month
			infrared sensor	
		solk seeds	sensor	52,910(device)
			regulator	\2,980/month

		chiba tusin system	door sensor regulator	¥53,000
		aito system	door sensor regulator	¥37,500
		art data	sensors regulators	¥101,600

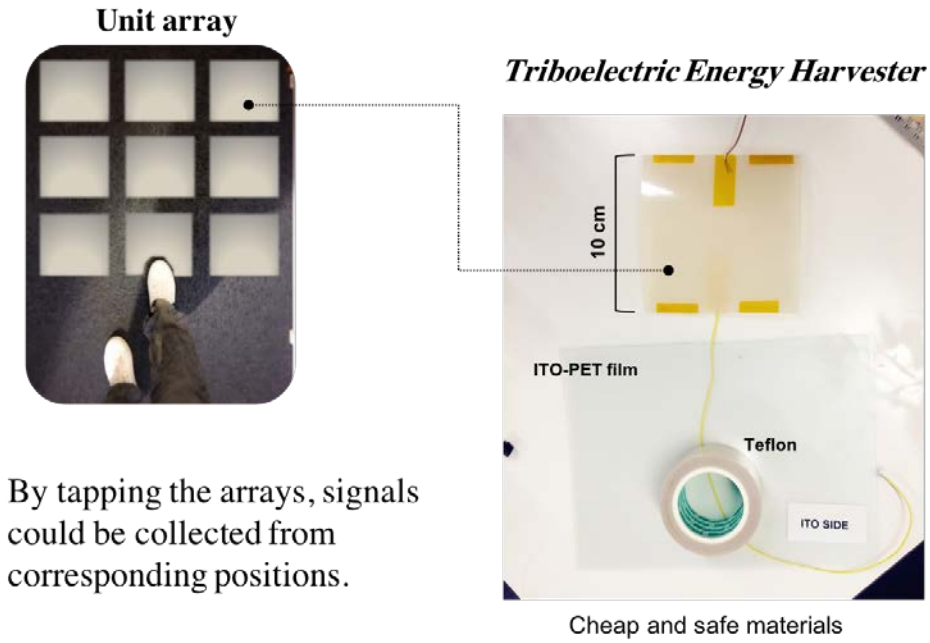
Other successful competitors are primarily designing devices that are hooked to the door or an invasive camera that is constantly monitoring a person who may wish to have some privacy. Furthermore, the cheapest device is approximately 3,000JPY per month, which could add up to over 36,000JPY per year, and for many years of monitoring would become costly for a family. Otherwise, the device could be purchased outright but then costs much more, as indicated by the table.

Furthermore, if we consider the usage of such devices that invade privacy or require electricity to maintain, the elderly person may not wish to cause such a burden on their caretakers for managing it. If the elderly person is suffering from dementia or other conditions that cause memory loss, there could also be a false alarm if they do not trigger the door or the placement of the sensor, etc. Therefore, our device fills a need in the market in that it does not invade privacy through videos while not consuming electricity or requiring the elderly person to manage their own movement in order to remind the sensor not to trigger an alarm.

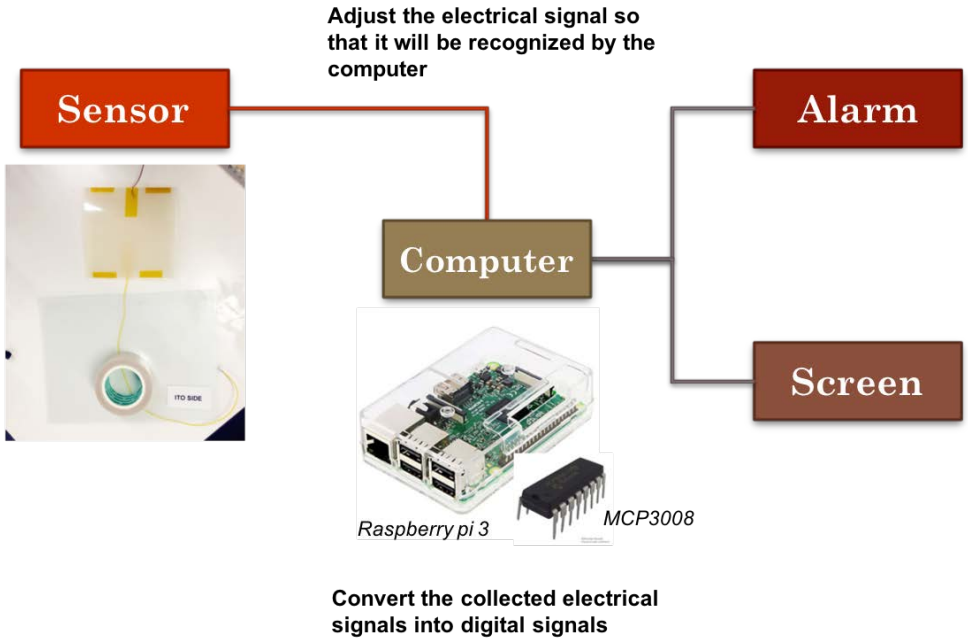
Prototype Design and Explanation of Service



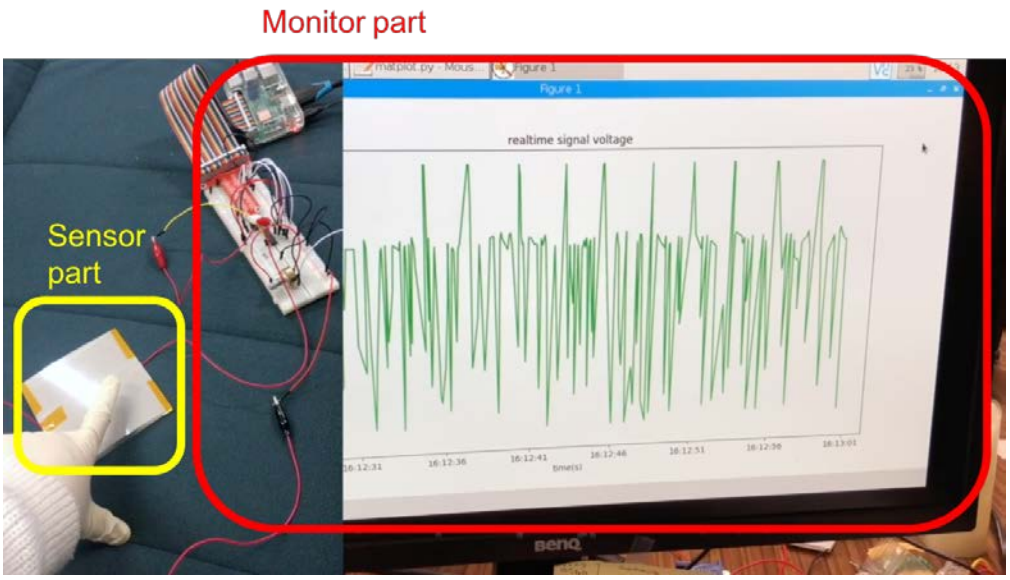
Develop a prototype of a self-powered sensor system to monitor the movement of the elderly in order to alert caretakers and medical personnel of any inactivity or trouble.



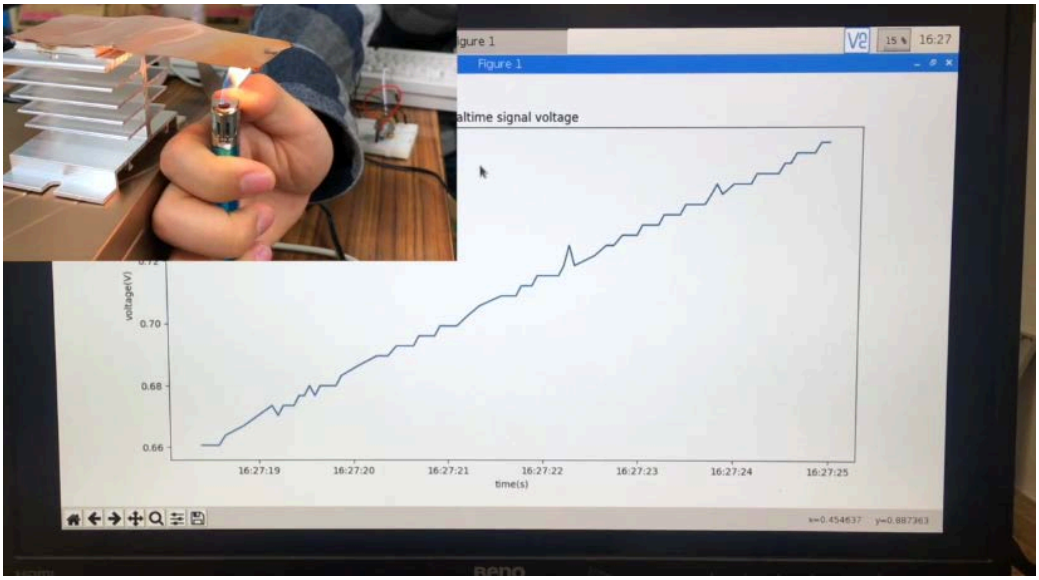
We made use of a novel technology called triboelectric energy harvester. Each sensor unit can convert external mechanical power into electricity.



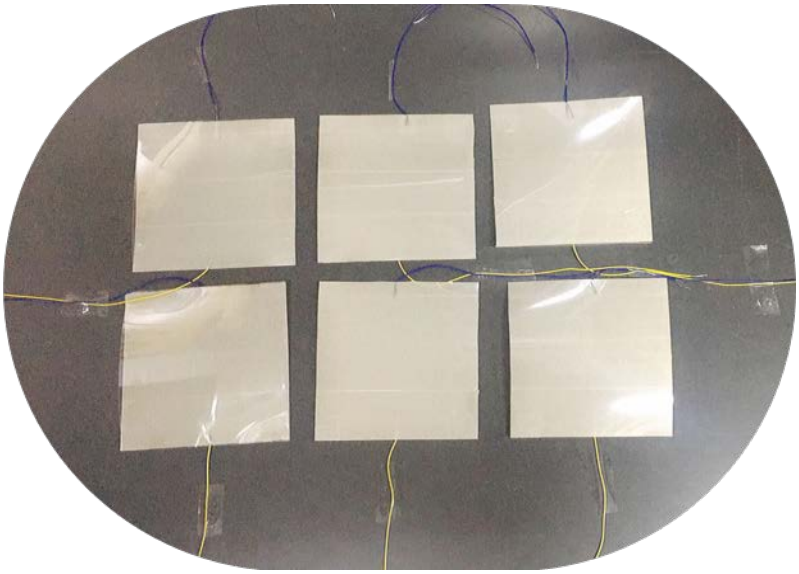
Our system could be divided into three parts. The sensor part generates electric signals. The signals must be adjusted by external circuit in order to be recognized by the computer part. Computer part's task is to convert the collected electrical signals into digital signals. Then digital signals will be sent to the alarm and screen of monitor part.



The sensor part is set in the living space of elderly people, and needs no external power supply. Just by tapping the unit, electricity is generated. The monitor part is for doctors and police. The whole monitor part is just a simple computer. It needs external power supply.



In addition to triboelectricity, we have also created a thermoelectric model. With its help, we can more precisely monitor the action of elderly people. We want to make the process fast, so we used very high temperature to show you its performance. Actually, human body temperature can also help generate signals, but cost longer time. This is an assistive technology to help us accurately grasp the information.



Sensor array will be integrated into a carpet. When volunteers walk on it, it is easy to gather information such as where the volunteer is or how often the volunteer steps here, etc.

Policy Recommendations

After completing stakeholder interviews and research on the target market, this team proposes several policy recommendations for society to address the issue of elderly living alone.

(1) **Incorporate more innovative policies and/or devices to assist the elderly**: Much like the prototype that this project team designed, there is a need for more R&D for providing services and products for our identified target market of elderly people, in particular those who live alone.

(2) **Partner cross-sector for initiatives such as private-public partnerships or social impact bonds for funding**: Through our target market analysis and competitive analysis, it became clear that there are two sectors working separately on covering the issue of caretaking for the elderly. If there is more collaboration between the sectors, there could be more innovative ideas that could serve our suggestion in (1). It is clear through the demographic analysis that the target market will only grow in coming years, providing a lucrative opportunity for private sector companies.

(3) **Consider more applications of this technology if it is further developed:** As the elderly people living alone market grows, there will be a higher demand for electricity in general, not only for caretaking. While this technology now can power a low-electricity sensor, by implementing more of this technology it could power more apartments without electricity costs or fossil fuel usage.

(4) **Build more family-oriented dwellings:** The high cost of housing in urban areas is a barrier for those who may wish to create a family and increase the native fertility rate of Japan. By providing better housing options and incentives for building providers, a long-term approach for combatting a low fertility rate could be devised.

Appendix 3. List of potential questions for interviews depending on sector

*Note: This is a list of all questions for all stakeholders. Some may be more relevant to others (for example, directly to caretakers or elderly versus policymakers, etc). **We may also add questions at the interview depending on how the stakeholder answers the questions, which may lead to additional insights, etc.*

Introduction: Briefly introduce the following and explain the objective of the interview below.

1. The interviewers and role in the group: name, year, department, etc.
2. The GSDM program and its goals: the Global Leader Program for Social Design and Management (GSDM) is an interdisciplinary doctoral program to train top leader's for today's global society. 21 departments are involved in an effort to develop students' talents in solving complex societal problems with innovative science, technology, and public policy.
3. The goal of this Student Initiative Project (SIP): our Student Initiative Program (SIP) is to create an innovative, low-cost, no electricity sensor alarm that can be left inside an elderly person's home and alert a caretaker if there is no activity sensed within a predetermined amount of time. With more and more elderly living alone in Japan, there needs to be an innovative way to combat the problem of untimely death or injury. (Draw a picture of the sensor prototype concept to explain our idea to the stakeholder).

Objective of the Interview: To gain more information about the business of creating a sensor device for the elderly, the situation for elderly living alone, and the needs of the market. Possibly also find out more about technological or policy constraints.

INTERVIEW: POTENTIAL QUESTIONS

Japanese Society, Government Health Officials, Caretakers of elderly etc. (understand the business & technological constraints)

1. How much of a problem is the issue of elderly people living alone for society? What are the main challenges?
    a. Suggestions: death, no caretakers, doing daily tasks, etc.
2. What are the main concerns of elderly who live alone for caring for themselves on an individual level (not as much for society)?
    a. Is there really a need for this kind of sensor application in their life?
3. How can we improve our project and sensor device so that it is useful to an elderly person living alone?
    a. Suggestions: low-cost, free through subsidies from government, donation program, volunteer support, no device option, etc.
4. What are the limitations of the current market?
    a. Why haven't other sensors or similar alert devices been successful so far?
5. What do you see as the barriers for this device being implemented in an elderly person's home? Are any related to government policy or fear of technology by users?
    a. What policies are in place that could create limitations for this device to be implemented in all of society?
6. Is there any other advice or a future you could imagine for this kind of product?
7. If we designed the best product possible, how would you imagine it would function?
    a. What kind of policy recommendations would you make?
    b. How involved would you want the government to be (national, local)?

Elderly Living Alone (Understand our customers)

1. What are your main concerns about living alone?
2. Would you feel relieved if there was this kind of system in your home?
    a. How could we improve the device to better serve your needs?
3. What would worry you if you had to keep this product in your home?
    a. Suggestions: risk of device malfunction, obstructive, lack of privacy, technology implementation, etc.
4. Who do you prefer to be notified if you passed away (death)?
    a. Suggestions: family member, caretaker, volunteer, apartment complex manager, hospital, etc.
5. Is there any other advice or a future you could imagine for this kind of product?
6. If we designed the best product possible, how would you imagine it would function?
7. What is your vision for a society that has more than 40% elderly?

For Private Sector Companies/ Technology Companies (Understand the business & technological constraints)

1. What kind of business plan and specifications would be necessary for a company to adopt this product?
2. What do you think are the main issues and target areas for elderly living alone in Japan?
3. What would a company expect the profit margin to be if they were to develop and market this product?
4. What are the expectations for a "minimum viable product" (MVP) in the electronics and/or sensor market?
5. Why haven't companies already created this product? (There are cleaning and caretaking services, volunteers who manually check on the elderly, etc.)
    a. Is a no-electricity, low-cost one enough of a "value proposition" to attract customers or governments to implement this device?
6. What is the budget and schedule you would expect if you were designing and creating this product within your company?
7. What are some success criteria we could use for our prototype design?
8. Can you think of any competitors we could research for our project?
9. What advice would you give to start-up entrepreneurs designing a product like ours?
10. Is there any other advice or a future you could imagine for this kind of product?
11. If we designed the best product possible, how would you imagine it to function?

Appendix 4. Email templates in both English and Japanese for reaching out to stakeholders and key informants

ENGLISH VERSION OF OUTREACH EMAIL

My name is _____, and I am currently a global health student at the University of Tokyo. I am reaching out to you to inquire whether it would be possible to interview you for 30-60 minutes as a key-informant and stakeholder in an innovative project I am currently working on.

To introduce the project briefly, a group of University of Tokyo students in engineering, frontier sciences, and global health are designing an innovative self-powered sensor device for elderly people living alone.

In Japan, an increasing number of elderly have few or no relatives to take care of them, and there needs to be a private and low-cost solution to alert caretakers when the elderly person living alone has not moved recently within their home due to either a problem or death. We hope to solve this problem with our self-powered sensor device.

Our group is gathering information through key-informant interviews by reaching out to stakeholders and experts in the field to ensure we design a device that meets the needs of our target group, elderly people living alone in Japan.

Might you be able to help us by allowing us to interview you for approximately 30-60 minutes one day next week or before December 15?

If you are unavailable before Dec. 15, we would also be grateful if could interview you after the new year.

Thank you for your time and support. We would be honored if you would be able to support our ambitious endeavors in successfully completing a prototype design suitable for our target group for the betterment of Japanese society.

JAPANESE VERSION

東京大学国際保健学科博士課程の_____と申します。

○○先生に、現在私たちが取り組んでいる革新的なプロジェクトの鍵となる情報収集のため、30-60 分ほどの簡単なインタビューをさせて頂きたく、今回連絡させていただきました。

プロジェクトの概要を説明させていただきます。

私たちが取り組んでいるのは現在大きな社会問題となっています高齢者の孤独死を防ぐための革新的な自己充電式警報センサーデバイスの開発です。このプロジェクトには、東京大学の工学部、薬学部、医学部などの専門の異なる修士、博士の学生が関わっています。

日本では現在少子高齢化に伴い、高齢者のお世話をする余裕のある若者が減少しています。そのため高齢者が一人で暮らすケースが増えています。この際に必要不可欠となってくるのが家族や近くの親戚に高齢者の突然の転倒や病気による行動の異変を知らせるデバイスです。安価で高性能な警報アラームセンサ

ーが求められている今、私たちは最先端技術を用いた効率的で高性能なセンサーの開発を目指しています。

そこで、_____の専門家であります○○先生に貴重なご意見いただくことで、日本の一人暮らしの高齢者というターゲットに相応しい製品のデザインにつなげることができればと考えております。

大変お忙しいところ恐縮ですが、来週の 12/15 までの期間で先生のご都合のよろしい時にインタビューに伺わせていただいてもよろしいでしょうか。

もし 12/15 までの日程でご都合が合わなければ、年明けにインタビューさせていただきたいです。

長文のメール失礼いたしました。ご貴重なお時間を私たちに割いてくださり、ありがとうございます。先生のお力をお借りして、日本の社会問題を改善できるような素晴らしい製品のデザインを目指します。ご検討のほどよろしくお願いいたします。

Appendix 5. INTERVIEW TRANSCRIPTS

a. Interview with Professor Kyo Takahashi, Institute of Gerontology, Aging Specialist December 13, 2017.

(introduction of GSDM, SIP, our project concept, etc.)

His questions for us to consider: What kind of technologies already exist? He has heard of sensors in the light? Or family/ housekeeping machines. What's new?

Important to show newness if we develop an idea for social design.

- clarify our strengthen value proposition.
- Panasonic maybe makes one?

People may want to buy this product in the context of security. In this sense, public officers may want to grasp this situation more than the individuals themselves. It depends on the final design of the product and its purpose.

Example: disaster preparedness. The public sector wants to know where those at most risk (children, elderly, disabled) are. Geographic information. The system would help.

Also, care managers could benefit from using this kind of technology if the elderly is under long term care system (health coverage type in Japan). To know the user's life and lifestyle.

(How many elderly are covered by this system?) Maybe the younger elderly in their 60s – less than 20%. So the majority are not using this system.

The majority are taken care of by their family members even if not living together. Or do you know *Minnseiiinn 民生委員*. Community security? Community supporters.

Major problem: cost of long term health care insurance. The trend is increasing as more people age and we need to reduce the burden of it. There is no stopping the increasing trend, but instead we can try to address better living in the long term. Try to minimize the costs or effects.

In my opinion living alone is not the serious problem. It is a natural phenomenom because people live longer than before and a spouse or family member could die. Those living alone will increase. We don't need to see that situation as a problem. But the cost of long term care is.

For example: insurance. Some older people are likely willing to be found by this sensor in case of an emergency. Some have an emergency switch to call 911. Willing to have that kind of technology. But maybe they cannot reach the button for some reason.

(Are there limitations in getting elderly to accept this kind of device in their home?) Yes, maybe it can be that we have to convince them. It is definitely useful for the watchers, family members, public officers, etc. It could be that we tell them about security management (of solitary death).

Organ donation example. → Japanese people must fill in when getting drivers license if they wish to be a donor or not. Maybe it can be implemented through the 民生委員 ? The care managers, they could do it on behalf of the public sector and could watch.

There is also a concern about managing the information itself. A lot of information on movement will be gathered and will be expensive to maintain and manage it. Who will do that? Maybe only store the information or only detects something strange and alerts? The signal could simply be 0 or 1. It depends on the final purpose and design of the device.

Limitations of current devices: elderly and family members can easily access each other via telephone or skype. If they cannot reach them, then the family member would check.

Maybe an application could solve this. They could know when the elderly used electricity or hot water etc. Is this market too small or too much transmitted information?

A major barrier at the policy level if trying to implement this through an organization or public institution: privacy of the caretaker and elderly. If they disagree to provide information, nobody can get it. However, disaster preparation doesn't respect the privacy law. Those groups can collect information of those at risk for disaster. No privacy in a

disaster context. Even so if someone wants, they don't want to disclose information to public sector or third party. In this case they are not on the disaster risk list.

(What would your ideal design to help elderly be?) Some machine to help their toileting procedures would change their quality of life. It affects their day to day. For those who cannot move, some kind of vacuum system in the bed to deal with toilet procedures.

Also, we must consider the social context. We are social animals. Older people tend to lose network. Friends and family members die. Generation gap between grand children. Social assistance technology. Could increase quality of life.

(Is there a barrier to relying on one another as elderly for peer support or social systems? Or for checking on each other for this solitary death?)

Peer education could be good for helping with new technology or quality of life. But other times it can be a poison because those in the same generation, especially the elderly Japanese, do not want to share or trust others around them. They do not open to just anyone. However, if the other person is younger or from a different generation, they are not in the same field and could accept help or being open with them.

Setouchi jakucho – monk woman? (90 something) Published a book for daily living. There is a book about how this older female monk accepts this younger Japanese secretary and her directness because she is of a different generation. it could be that Japanese culture of the elderly limits reliance on one another for social support.

Another aspect of lack of trusting others in elderly is that to be older means to be cognitively impaired and depressed. These are age dependent factors.

What is your vision for being part 40% of the elderly society?

"sustainability" key word. We probably need more immigrants if we pursue the productivity. If we change mindset from productivity to happiness or some other measure, the activity would be different and maybe don't need as much productivity.

Also that 40% of elderly in overall society will be my generation once we grow old!

How about AI helping with productivity or taking jobs, affecting mental health of the world? Well, technology is important if we look at productivity. But happiness is not made by only that aspect. If the technology compensates for our losses in aging, it could be welcoming.

If he needed this device in his home as an elderly, who would he want to contact or how would it work? Honestly, for him after he dies it doesn't matter. Some elderly prepare more and want organization. For him it won't matter.

b. Interview with Ishihara Kana San, Social worker for elderly(社会福祉士), December 13, 2017. 地域包括支援センター、横浜市新羽ケアプラザ

(introduction of GSDM, SIP, our project concept, etc.)

<The situation of the elderly people>

300 people out of 3000 are now living alone around Nippa region. Some of them live alone in their home because they don't want to leave their own home. But many are willing to get into the Nursing home but cannot because so many people are waiting for the vacant and only rich people can get into the private Nursing home.

They also afraid of falling down when they are alone. No need to say that good sensors are in demand.

<The situation of sensors used>

Often the sensors used in elderly's home is just a emergency button. When they are in real danger and cannot reach to the button it is useless.

Nursing home or hospitals use nurse call for the emergency. And they also use sensor mat. When patients topped over, it will alarm the care takers.

Ishihara san have never heard nor seen of other kinds of (high technology) sensors before.

<What kind of product is needed?>

1. Easy to use (No need to operate by elderly people)

2. Cheap

3.Alarm family member or guardian in the case of emergency

(There is a high possibility of getting hooked up by the law of privacy if you alart the police officer. It's better to contact family members through the sensor.)

<Problems>

・It is difficult for the community center to catch up all the data of the elderly people living in their district.

・The pension of the Middle class people is too low. (There is no subsidy for the middle class people.)

・The number of Nursing home is insufficient.

・The manpower taking care of the elderly people is insufficient.

<Ways to solve the issue of aged society>

・Let healthy elderly people to take care of the neighbors who need help.

・Prevent ourselves from being various disease and becoming a healthy elderly people who don't need any medical treatment or care.

→the community center has already tried to execute these counter measures, however the real situation is not that easy.

c. Tatsuya Honda, Fujitsu Researcher and "Forbes 30 Under 30" interview (January 28, 2018)

He designed a small vibrating device that transmits sound vibrations through hair follicles for feeling sound for Deaf people. Called "Ontenna" and conceptualized during his university studies.

How did you come up with the original device concept?

Designed "ontenna" device during university. He often worked with Deaf students and created a circle and NPO to support them when studying sign language. Then thought was there another way he could use his design and engineering skills to help them?

These people cannot know if animal barks nearby or if a phone or alarm sounds, etc.

The idea was also based on cat fur and how they can feel sound around them through their fur.

How did you move from prototype in college to a new design?

He won a small grant for young students to design innovative products and managed to then move beyond the original wired device to a wireless device.

The vibrations were first on the clothes or skin. But "kimochiwarui" (didn't feel good") or "mahi" (numb) etc, and on clothes was "wakarinikui" (hard to feel/know).

Then they decided the hair could be appropriately sensitive but still enough to know when it vibrates.

When you came up with the hair concept, did the test user tell you directly or did you think of it? How did you make the connection?

They designed several prototypes and tested and remade it over and over. Eventually as they eliminated options they could come up with this idea.

For example, people who can't hear at all or use any cochlear implant, they need vibrations for feedback. Originally they made a visual light bar that is low for small sounds and bright for big sounds. But because Deaf people use so much visual input for information, they are stressed when they see these lights abruptly and would rather have tactile feedback.

Then they had to decide where to then have the vibrations.

Was it a large group of testers? Someone different every time? Or the same one tester?

Actually, it was one tester. Sometimes after a round we would ask a few others, but generally we would only have one or two same testers try and give feedback each time.

For example, they tried it with a vacuum cleaner (it would unplug and Deaf person did not know and would continue vacuuming. As long as it was vibrating they know it is working.), a doorbell and others – it vibrates along with the sound pattern of the original sound.

How about trying to include others outside of the Deaf community?

So we worked in schools and could watch the students actually try speaking to feel the vibrations. Usually they don't use their voices much.

They did a tap dancing event in Shibuya to allow the public to try wearing them and experience watching tap dance with the device in their hair, both Deaf and hearing people.

So how did you move from the original basic prototype to the next iteration?

He was close to the final users and need to know exactly who is using it and what kind of environment. Then he had these testers try it many times.

How did you choose your original target group then?

An exclusive group or only that group. For example, we originally marketed for Deaf people who really love technology OR do not use technology at all. So in the beginning really try to focus on the target. Then you can expand to another group.

Something else we considered was there are many devices to kind of help them in emergency situations or safety reasons, but nothing that simply enhances their quality of life, such as being able to listen to music. This product could help them do that – and conversely, the product can then move beyond only this market to hearing people as well.

So how did you then get picked up by Fujitsu? Did you have a specific business plan or a pitch? What materials did you need?

So we simply pitched it by meeting a connection. Honestly, there was no business plan or anything else needed. All they wanted was the passion. It has been a 2 year project and will have final judgment in June. Fortunately the Mito grant helped the initial prototype to show how it could be a reality. That probably changed everything. I quit Canon when they wouldn't try my project and Fujitsu said they would try to help me.

So at Fujitsu now, do you feel they are accepting of this passion only or are looking for business profitability and other aspects?

Interesting you ask that because now we are building a schedule for final milestones. There have been a few shut downs regarding how the target segment is too limited and how this technology can be expanded to other groups who can purchase it.

(After introducing our SIP project)

I like the idea of trying to use the advanced technology in its current applicability now rather than continuing to wait for the research of tomorrow and wearable chargers for phones, etc. Could there also be more way to expand it to those who truly have no electricity? I could also try to introduce you to someone 65+ living alone in Japan to test it.

Make sure to have the prototype first and continue testing it as you go with the target segment rather than finish the prototype then test it. Do it as you go.

Something we are trying to do now is rather than have the people test it for only one day, they use the device for awhile and give feedback. They could take a picture with a polaroid camera and write notes of their feedback in that moment. Then they collect the pictures and consider how to update it. This may be too difficult to explain to an elderly person to do. Maybe just taking notes for ideas.

I want to know how to connect the sensor – doesn't it require electricity to transmit the data? Skeptical as to its true no-electricity possibility.

So back to Fujitsu – were there ever blocks to your ideas? How did you expand further with your idea when this happened?

Sometimes with Fujitsu – how to expand further when blocked because of money. We decided to try to make it more like an accessory rather than some limited use. We also go to the field and test it directly with the deaf schools or maybe working with the NPO to reach target market.

He is also working on ALS patients for new project. Moving eyes with tracking eyes.

Welfare products – always the negative point. The customer or patients will tell you what they don't like about life and you try to focus on that one point. You can't resolve all the problems.

(for example, sound is loudness and frequency, but ontenna only focuses on loudness)

When it comes to implementing or distributing the product, have you ever had to try working with the government service to use it? Or only the private sector?

trying to do it only through private sector – and then maybe if not then do public sector.

Because it is an accessory. Trying to avoid working with the government because all of the paperwork and bureaucracy holds the ideas back.

What are some of your ideas for milestones or targets along the way?

Marketing strategies are at the deaf schools or events instead and then spread it out to the schools. Even for Fujitsu now it is an original case. Welfare product.

We had the Prototype, vision, user's face – showing them actually using it and that convinced them. How they experienced it.

They're in the planning stage now for future ideas. Trying to do something by the Olympics to be more inclusive.

They want to sell one real set of the current device to a school by June, in addition to collaborating with 4DX movie theaters for a cheaper better experience.

What happens if Fujitsu doesn't approve the project beyond June?

Then I probably quit and find another job! But there has been a bit of press about this innovative helpful product with the Fujitsu name. I doubt that would happen. But it has been 2 years and 6 months. It took longer than I expected to get to this phase with many barriers such as approval of testers and other issues. It may be easier to do these initial studies in a university environment. Such as liability if they get injured while testing your device, etc.

What would you be doing if you didn't have Ontenna project?

Probably still designing user interface for printers at Canon.

How do you define success along the way?

I take pictures of my user using the product to show its value in the market. Choose the target market exactly. Try to have them test it while you're still prototyping it.

Any other advice for our project?

Maybe you could check out Todai Hospital or some government housing area.

How does this compete with a motion sensor? Be prepared to fight other good and/or existing ideas.

Maybe you can track the level of pressure for a fall compared to a step.

Or during the earthquake there were electricity blackouts. Could this contribute?

d. Yamamoto Yuji interview, CEO of Minacare, Jan 30 2018

(Brief introduction of the project and asking for business advice especially as it relates to healthcare management)

Main things you need to consider are what man power, technology, resources within existing company do you have now?

It is your own property? Get a patent? If not engineers. If it is someone's property, you need to get license and pay the license fees.**

Who is actually paying for the product for profit? Who is happy using this product? Not only "iine" or that's nice. Think of who would think if you didn't have this would probably die and want it, etc. Then try to design it for this person.

(Go-san: the old person is still worried about self. So family does it for them. But because nennkinn is not enough, can't get device).

How do you approach them for this marketing? Who and which channel for how much?

Cost vs price are totally different – the in between is more important for profit margin. WTP.

Strategic price? How is it that your team knows why it's your product low price and if others can quickly imitate it then it'll get repeated. The core technology must be yours for patent.

You could be supplier for existing sensor companies. Instead we are trying to sell a service through multiple stakeholders.

Say if others don't feel we need the alarm all the way to the police or other groups. Even if it is just through the health care providers. Try to scale up once you try with nurse or human capital.

We don't want too much alarming or low alarming. → what is the threshold? Need to really change it to needs to work **

Instant business model? Could be that you are only a supplier to a service provider that already exists in this context. Then work with engineers to get exclusive licensing contract.

No incentive → who really worries about it? *Lisa: Building manager when people pass away unnoticed is a large one.*

Target customer should be property manager or construction? You could argue that the cost is lower if we find them earlier.

You could also consider the "Job to be done" – not just want to do. They want a tool to do the task that no one wants to do. Not just nice to have, but it is needed.

So if it is a service or supplier: How many sensors or elderly people can this person watching them through the software manage?

Does the customer pay for the person managing it, their hourly rate? etc.

How much does each customer pay for this watch person?

Is there a place that has enough to cover the costs of the watcher?

When does the service come? After the alarm goes off – the minutes. Is it a 2 minute delay, 10 minute delay, etc. Maybe doesn't actually help enough.

Lisa: Yes, in USA everyone likes to sue each other at the slightest problem. What if someone did not respond to the alarm in time?

Could do simulation to see if everyone falls down/ sets off alarm too much and how response time with caretaker.

Also think bigger picture for the market. How many times in one year do these phenomena happen? How many die or have to find this data? Not just die but fall down and then hospital? How much frequency? Not so low risk? Then becomes capital intensive.

Be a device supplier first.

(maybe cut the people who do programming etc. branding)

Not only find possible customer but have to find some partners for scaling up and testing phase. Even if we did want to implement it.

Something else to consider: is it acceptable to you if only the company profit goes up? Etc. For example, you give them a lower price so that the elderly people can access it – but if the company doesn't change the price and only gains a larger profit margin, then maybe you did not meet your goal to truly help people. This must be built into the contract.

The time gap of operating costs/ cash – when you have to pay suppliers or manufacturers before you get paid for your product. Cash is always king in business. Even if you make profit on profit/loss (PL) if your cash flow you will be bankrupt because people don't wait.

If only device supplier and payment interval.

Maybe if only MVP and licensing. Then if they're interested in your patent or license, then they will pay you in advance and could be lighter. Instant profit. Just give away the patent license instead?

Whose patent is it?

If it becomes team's property, who can divide up? Why can you be a team member of the patent? What's your value to the patent?

What if a company comes and offers more salary for the patent, and you fire the non-essential person. Build a contract in the beginning for mutual commitment or agreement. Team building essence. *(Lisa: this is like marriage.)* Haha! Yes.

Any other advice for us?

Why not talk to service places? What are the needed service parts for that idea? How many years can you use it and then replace it?

Not the end user. Industry side who is struggling to make the right market or product? Often the problem with this "mimamori" products is no one can sell them. No one actually buys them. Find out who will actually hand over cash for this technology. As you meet more stakeholders, you can try to also identify potential business partners for if you do produce the product.

Lisa: what about if AI reads the data instead of a human watch? The government would definitely be more on board with this concept.

e. Tomihara Sayaka interview, Deputy Director, METI healthcare industries division, January 31, 2018

(briefly describe our project and goal of interview)

So the first thing to consider is who is benefitting from the device itself? Of course the elderly but also nursing homes or children who live far away. It may be easier for the staff who work for elderly people.

The local government may have a benefit. But there is a concern – is it actually cost saving or not? Yes, it can be good to do preventive measures that allow them to live more actively and longer. However in this case it is only an alert system.

We are using SIB (social impact bonds) as a funding mechanism for some new innovative technologies in this area. The way to use this is to see if you gain more later or somehow now, etc.

**Something she wants to know: Is it waterproof? Could it work in the bathroom? Most elderly people don't fall down in the middle of the apartment as much as in the toilet when sitting and getting back up, or in the shower or bath tub.

We have some feedback that they want a wearable device that is also water proof.

Lisa: Yes, and if they are elderly maybe they forget to charge existing waterproof wearable devices. Something unique about our device is that it requires no charging or battery operation. And for maybe elderly people who have dementia.

Yes, this is certainly a concern. Maybe in the bathroom they also have increased blood pressure from the temperature of the water.

Something else to consider may be what does this replace if we use the device? For example, maybe have it alarm more during the testing phase to be sure you don't miss any problems, then as it is optimized and improved from feedback can know what the alarm threshold may be.

As for this – is it a service or a supplier? May want to consider only supplying rather than a whole system as this costs more and more confusing who to apply to. Some businesses have an option where they add this security feature on to home security services in general. This helps elderly feel safer.

SIB schemes are interesting but take a lot of time. Local government fairly large scale not just five or ten homes. Need larger scale. Building managers may be a good idea.

What are some of your main concerns as you work on active aging and other policy areas?

Medical issues and elderly nursing issues. For the latter, several issues not addressed. As you mentioned, they are very lonely. To have them continue to work or connect to the community. Some academic work shows that those who are involved in community do not fall ill like those who are lonely. So now there is evidence that community involvement prevents illness which helps the cost of caring for illnesses.

This is especially the case for men and women. Women are better getting into community to be more involved. For men, it is hard for them to find a new role in new context after retiring at 65. How to empower active senior people.

Another concern is the payment and incentive system of health care workers. Payment system for elderly care in nursing home, if they get sick, the health care worker gets paid more because time and expertise. So now there is no incentive for elderly to make the individual get better. It is not a good business model.

On the ground level. Compare to medical issues for a disease, if you prescribe a medicine it makes you better. We are wondering what kind of nursing care will make them get better? Misplacement of incentives, good stories of nursing homes that empower and improve their illness. But these are only stories. Only stories is not enough to change all of nursing in Japan.

Lisa: (positive deviance of which ones that are good?)(what is the measurement of good?)(involvement in community during working age years?)

Lacking workforce to care for elderly people. How to improve elderly's condition. Now is only taking care of them and watching them go down. Hard job. If we could show them somehow that their efforts improve the conditions, more people may be motivated to help.

Disincentives for workers, plus lack of workers. Evidence-based good methods is not enough.

Change the work style of Japanese population so they can stay connected to the community even if they get ill. As your model shows, lonely elderly will increase.

Finding a role for themselves – women can do this. Men when working for 50 years cannot find a new life. No big hobby or volunteer activities. There is a hierarchy where people listen to you at work once senior but in real world it is more flat.

Lisa: (private sector elderly alumni association?)

Continuous care retirement communities – in USA ? ** check.

They create them near universities. Senior place next door. Another department is trying to start a new initiative like this. Borrowing idea from US. Didn't go well because went out to rural areas branding. She still thinks this idea could be successful if rebranded.

Lisa: Do men cost more as well? She hasn't looked into it. But she does believe that most business workers sharply cut off involvement once retiring around 65 and go downhill from there. If it could be more gradual, they may be healthier long term.

Women 10% have steep decline and die or bedridden, 90% slow deterioration. Versus 20% of men are steep decline or die/etc, 70% slow decline, and 10% are actually genki. *(Who are these 10% genki men?)* She says they are mostly leaders or worked many extra years in high-level positions, shachou, etc.

Is declining fertility is in the same issue but very separate?

After 2042 the elderly also decrease too. Not having enough children is the bigger problem. If parents have to be cared for it affects lifestyle of children. Certainly fertility is the larger issue in this problem.