Title: Integrated Rescue Service Satellite (IRS-Sat)
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[x] **We apply to Student Prize.**

1. Key Concept and Business Impact on Society and Environment

The number of natural disasters increased in the past decades taking away the life of thousands of humans. In this paper, an idea is presented that would be used to provide a robust and secure satellite rescue system to guide in assessing the severity of natural disasters in affected areas and help the rescue troops to plan their logistics more efficiently and effectively. The system targets South-Eastern Asia, which is the most likely area to be exposed to natural disasters in the coming decade [1].

The idea's concept as shown in (Figure 1), applied to the case of Japan and Indonesia for the purpose of illustration, is to develop a rescue based system that enables users to send messages before, during, and after disasters to satellites from their smart phones via distributed communication nodes. The satellites would further forward the received short and simple messages to distributed ground stations that would relay the messages to rescue and information processing centers to help in assessing the severity and type of danger.

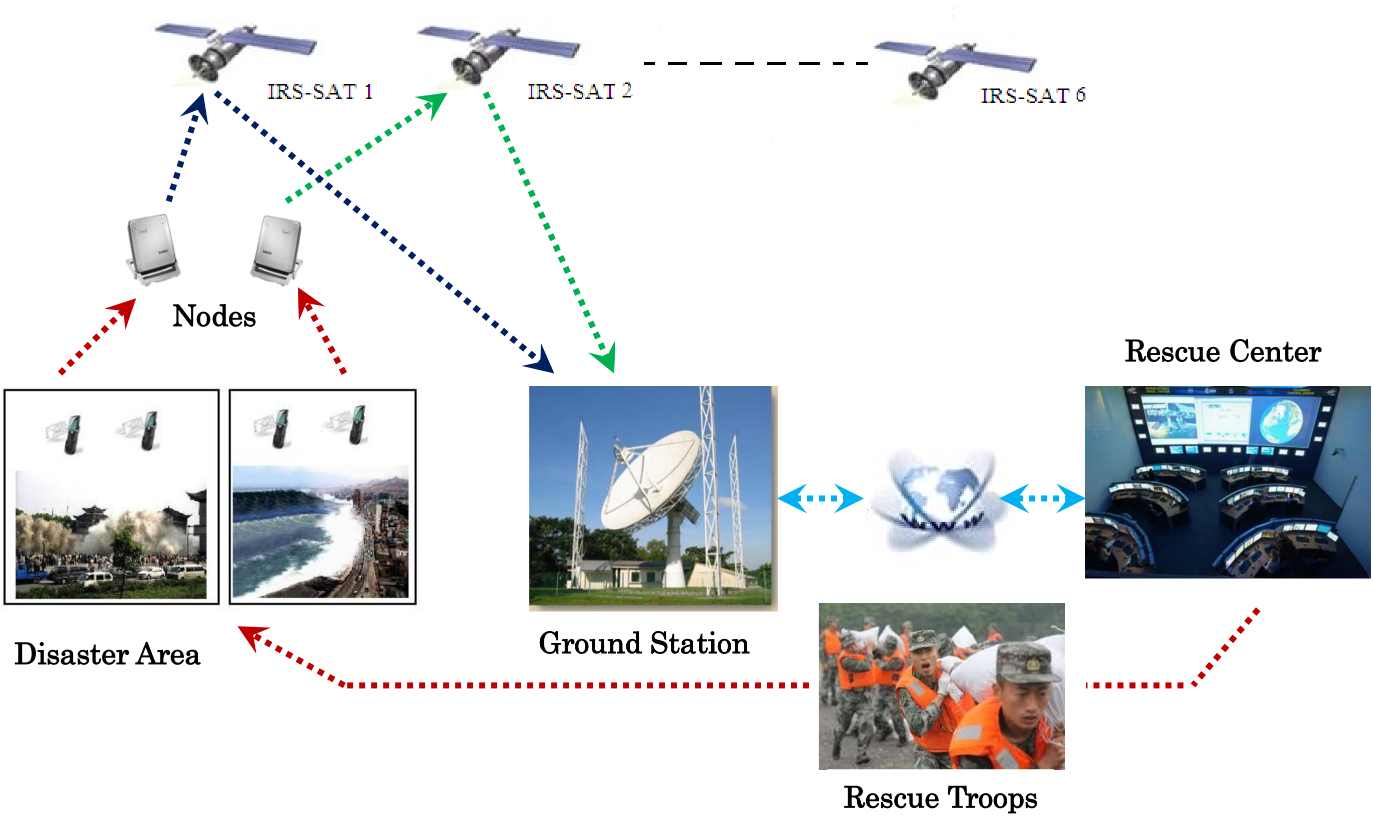

Figure 1. Concept of the IRS-Sat system.

A danger map showing the country segmented into blocks, each covering a 10 km^2 area, will be generated and updated based on the received user signals to represent the severity of danger in each block. The 10km^2 area limit was determined based on the population density in Japan and Indonesia [2]. Each smart phone would communicate with a node terminal through WiMAX/Wi-Fi technology. The nodes will act as multiplexers to gather all the messages sent by the users and perform statistical analysis on them. An overall consensus message will then be sent to the satellites indicating the number of users, the type of danger and the severity of the threat they are facing. To satisfy this requirement, the users would have to choose the type of danger they face such as floods, volcano, earthquake, and/or tsunami on their smart phone specifically developed applications. The users would also have to select the severity of the danger from easy, medium, and high as well as the number of persons seeking help.

The nodes operate in two modes, normal condition mode and disaster mode. In normal condition mode, the nodes act as a distributed ground sensor network for collecting environmental measures to help predicting natural disasters and provide an early warning system. In disaster mode, they act as data packets multiplexing units to reduce the overall traffic that is relayed to satellites.

The mission can be described as "an economically affordable and simple service that helps minimizing humans' sufferings and provides peace of mind". Other satellite systems that offer rescue and monitoring services such as the Disaster Monitoring Constellation (DMC) [3][4], the African Resource Management constellation(ARM) [5], and SPOT [6] do exist. However, the system that the IRS-Sat team presents is focusing mainly on covering South-Eastern Asia with high revisit times. It helps guiding the management of resources and logistics during natural disasters, assessing the actual level of danger and its type as faced by habitants, and making the rescue service more communal and accessible by providing it not only to governments and authorities but also to a wider group of domestic users.

The IRS-Sat is expected to improve the lifestyle of people by allowing them to have peace of mind through a confident sense of security. The system would eventually have an impact on the telecommunications industry to design, develop, and manufacture a ruggedized node that would stand the severe disaster conditions, be self powered and would operate autonomously with no need for remote operation. Information technology industry would also be affected by the development of reliable software packages to be run on smart phones and in the future on specific tablet PCs. To judge the success of the idea, field surveys will be carried out to measure the satisfaction level of the subscribers. The net revenue generated would also form an important measure of success. For the future adoption of the idea on a large scale, recognition by the international society is sought through obtaining an ISO certificate for customer satisfaction and quality of service in addition to joining the UN-SPIDER network [7].

2. Business Model Structure

Who? Governments and private sector investors.

What? Assessing the severity of natural disasters in affected areas which will help managing rescue resources effectively and efficiently.

Why? No rescue services that focus specifically on South-Eastern Asia, whereas this region is the most prone to natural disasters. Provide a Low cost service that is accessible to a wide group of customers using their already existing smart phones.

Where? Indonesia and Japan because those are the two countries with the highest number of natural disasters occurring due to their geographical locations [1].

How? When a natural disaster occurs, the user sends a message using his/her smart phone to indicate the current disaster severity according to his/her point of view, the type of disaster that took place and the approximate number of people in need for rescue. Data are sent to nodes, which counts the consensus among messages regarding the information which they contain. The node relays the gathered data to the IRS-Sat, which sends back the data to remote ground stations and their backups. Using the internet, the ground stations send the data to rescue and information processing centers. Rescue centers can respond accordingly by organizing their activities and specific resources as needed in the targeted areas.

When? 10 minutes communication session every 110 minutes with a constellation of 6 nano-satellites and 4 ground control stations.

How much? Since the countries prone to natural disasters do not present the same Gross Domestic Product (GDP), price discrimination policy will be applied [8]. Estimate of the application charge and monthly subscription fees per user is shown in Table 3.

3. Business Feasibility

Tables 1, 2, and 3 present the initial fixed cost, the annual variable cost, and the annual revenue of IRS-Sat service. Figure 2, total cost vs. total revenue, shows that this business idea is viable and reaches its breakeven point after 1 year and 3 months within a total operating period of 5 years which corresponds to the satellites' lifetimes. The overall target customers were limited to the current ratio of population who own a smart phone. Linear annual increment of new customers is assumed over the 5 years of operation. The total Return On Investment (ROI) is in the order of 30%. All values are estimated in USD.

Table 1. Initial fixed cost.

	Item	Level	Quantity	Cost [M$]	Total cost [M$]
1	**Ground Station**	20 Mbps downlink[a]	4[b]	0.5	2.0
2	**Satellite**	Payload(9.6 kbps uplink)[c]	6[d]	0.8	4.8
3		Bus (high level)	6	4.0	24.0
4	**Software development**	Smart phone application	1	0.1	0.1
5	**Node**	Ruggedized design	326,409	0.001[f]	326.41
TOTAL					**357.31**

[a] Uplink speed: 1.2 kbytes/s, [b] One main and one backup ground stations in each country, [c] details in logistical feasibility section, [d] From orbit and coverage simulations, [e]36449 nodes for Japan and 181157 nodes for Indonesia plus half of this quantity as backups, [f] The cost include the installation of the nodes.

Table 2. Annual variable cost.

	Item	Quantity	Cost [M$]	Total cost [M$]
1	Ground Stations operation	4	0.4	1.60
2	Node maintenance	326,409	0.0001/month/node	391.69
3	Marketing			0.60[a]
TOTAL				**393.89**

[a] Around 10% of the total revenue.

Table 3. Annual revenue.

	Item	Smartphone users	Annual subscribers	Monthly fee [$]	Annual Revenue [M$]
1	Subscription in Japan	21,590,000[a]	4,318,000	10	518.2
	Subscription in Indonesia	12,410,000[b]	2,482,000	5	148.9
2	SW package in Japan	21,590,000[a]	4,318,000	0.17	8.81
	SW package in Indonesia	12,410,000[b]	2,482,000	0.08	2.48
TOTAL					**678.39**

[a] October 2011, 17% of Japanese had a smart phone [9], [b] Estimate of number of Indonesians having a smart phone.

4. Logistical Feasibility

Message sent from smart phone to any node is 6 bytes in length. The total data size sent from all the users in 10km^2 region is expected to be 22680 bytes in Japan and 8280 bytes in Indonesia. Size of message sent from node to satellite is around 26 bytes. Thus for Japan, total data size of around 1 Mbytes is the maximum be uploaded from the whole country nodes simultaneously. Multiple access to satellites is required. Nodes are used to multiplex the data coming from users, hence reducing the number of points seeking simultaneous multiple access. The total time needed in Japan to upload all nodes' messages, sequentially, is around 14.5 minutes, at an uplink speed of 1.2 Kbytes/sec; about 69% of the messages would be relayed to the satellite in view. That is a fair ratio as it is not expected that 69% of the country will suffer disaster at the same time. Overall system reliability is maintained through nodes' backups and constellation (6 satellites).

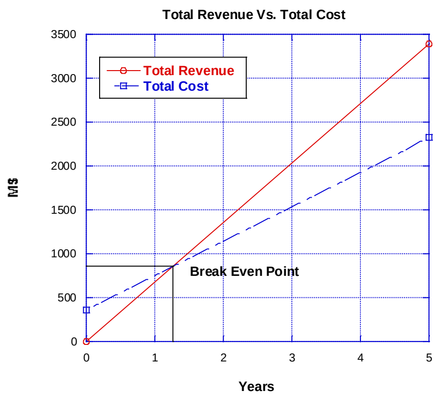

Figure 2. Total Cost vs. Total Revenue, Break Even Point.

Payload and Bus Level	Communication payload: 9.6 kbps (Medium), Bus: 20 Mbps (High).
Number of Satellites and Orbit Coordination	6 nano-satellites in the same coordinated LEO orbit at 50.5° inclination and 600 km altitude.
Ground Stations	4 ground stations: (1 main + 1 backup) stations in each country.
Launch Rocket	DNEPR rocket goes to 50.5° orbits [10][11][12].

5. Risk Analysis

Table 4 presents the risk analysis for which the ECSS standard was used [13].

Table 4. Risk analysis

No	Risk	L[a]	S[b]	APO[c]	A[d]	Contingency Plan
1.	Early failures due to technical difficulties during the satellites development	D	3	Scope	Medium	Sub-Contracting based on companies' competency level
						Insurance on the satellites to re-build in case of failures
2.	Service unavailability during disasters due to malfunctions	C	5	Quality	High	Backups for the nodes, ground stations, and satellites
3.	Service cost is high	C	5	Cost	High	Use price discrimination policy
4.	Legal and Political constraints	C	4	Scope	Medium	Coordination with local governments and authorities
5.	Destruction of any of the ground segment components during disasters	D	5	Quality	Very high	Use ruggedized components
						Modular design for quick repair
						Insurance premiums for revitalization
6.	Securing the needed financial resources for building the whole system	D	4	Cost	High	Issuing common stocks in the securities market
						Public-Private partnership
						Insurance companies and banks as target investors

[a]L: likelihood, [b] S: severity, [c] APO: affected project objective, [d] Assessment

References

[1] http://earthquake.usgs.gov/earthquakes/world/world_density.php

[2] United Nations Demographic Yearbook, 2009 – 2010, Economic and Social affairs, http://unstats.un.org/unsd/demographic/products/dyb/dybsets/2009-2010.pdf

[3] http://www.sstl.co.uk/news_and_events/latest_news?story=1254

[4] http://www.dmcii.com/

[5] http://www.saao.ac.za/~wgssa/archive/as12/mostert_new.pdf

[6] http://www.findmespot.eu/en/

[7] http://www.un-spider.org

[8] https://www.cia.gov/library/publications/the-world-factbook/geos/id.html

[9] http://www.newmediatrendwatch.com/markets-by-country/11-long-haul/54-japan

[10] http://www.kosmotras.ru/en/rn_dnepr/

[11] http://www.arianespace.com

[12] http://www.jaxa.jp/pr/brochure/pdf/01/rocket01.pdf

[13] ECSS-M-00-03B Space project management – Risk management, 16 August 2004.