Cairo University-Faculty of Engineering
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Title: Stranded Traveler Tracking System

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Need

Many individuals take adventurous travels in unknown and uncharted territories such as Sahara, ice regions, mountain climbing and sailing around the world. The individuals taking on such adventures usually take these trips alone and with limited equipment and there is always a great risk on their own lives. Sometimes even large groups of persons in safari trips or on board ships in the oceans get stranded and need help and locating of their positions in the midst of what is usually vast unfriendly environment. This mission concept addresses the need for a space system to track the motion of Stranded Travelers and provide warning and location for the rescue teams.

Mission Objectives

-To track the movement of single or small groups of travelers traveling in remote and harsh environment or of ships.

-To receive, collect and process normal or distress signals of travelers via constellation of satellites carrying transmitter-receiver devices and imagers.

-To predict next location of travelers based on information contained in the signal (location, direction and speed).

-Take an image of the convoy or the ship in its surrounding while en-route to be used for comparison and identification in case of emergency.

-To send images and coordinates of expected locations of stranded travelers and convoys in case of stress or cut-off of contact.

Concept of Operations

The mission operational concept is as follows:

1-The traveler will carry a **transmitter-receiver** (Traveler's Transmitter- Receiver) which sends two types of signals, the first type is a normal signal every say, 6 hours carrying information about current location, projected direction and speed. This information is either extrapolated automatically from past trip segments or introduced manually by the traveler. The second type is a distress signal entered by the traveler carrying similar information. The exact type, frequency and contents of the signal are not fully developed at this stage and will be designed at a later stage as part of the mission design process.

2-Each individual traveler or a convoy who subscribes to this service before leaving home will have a code number for identification which will be registered before traveling. This code will be used to record and store tracking information under it. It's like a subscription number.

3-The signals are **received** by any satellite in the constellation which happens to be in the visualization/communication zone of the traveler's path. The **constellation** contains enough **satellites** to cover communication with any point on the globe (communication zone depends on the orientation of the signaling device-If directed vertically then it can communicate with any satellite within approximately 200km of the site). This is a design parameter for the constellation number, altitude and coverage.

4-The signals are transmitted immediately to a **control station** either directly by the satellite which received the signal if it happens to be in the communication zone of one of the control stations (3 stations) or via another satellite. The **system for transmitting** the signals and prioritizing them and **deciding** to which satellite it has to be sent is to be designed at an early stage of mission implementation.

5-The closest satellite to the site of the traveler will take **frequent images** of the location from which the signal is received. These images are stored and used for ease of identification of the terrain in case of distress. The location of the signal source can be obtained by some sort of triangulation or locating algorithm. The locating algorithm is in this case a two dimensional spherical geometry problem.

6-When the system either:

-receives no signal from a traveler for three consecutive intervals, or;

-receives a distress signal from the traveler.

the system will initiate a process of **search and rescue** by sending the latest position location and images the predicted location and image to rescue centers and teams.

This ends the **Monitoring, Tracking and Warning** task of the Space System.

7- Another task can be added is receiving messages from the families and friends of the travelers through the Store-and-Forward system installed on the satellites and which communicates with the hand held Traveler-Transmitter –Receiver.

System Components

Ground Segment:

1-Traveler's Transmitter-Receiver: the traveler carries a signaling device which sends two types of signals; **Normal signal**, sent automatically at regular intervals of say, six hours and **Distress signal** which is activated by the traveler in case of distress.

Each signal carries an identification code and information about the location (latitude and longitude). There will be a version of the scheme which does not need the location information and can generate it through the system itself.

2-Receiving Stations: A number of stations (3-6 stations) distributed over the globe for receiving and retransmitting signals from and to the constellation. The number and location of the stations is a key design parameter.

3-**Control station:** This station receives all signals and processes the information. No processing is done on the satellite.

Space Segment:

The system consists of a constellation of satellites consisting of a large number of nano-satellites each carrying communication and imaging payloads.

Communications payload

Consists of the following:

1-**Transmitter-Receiving unit.** To receive the normal and distress signals and transmit it to the control station or another satellite.

2-Signal Processing unit. To process the signal, identification code.

- **Imaging Payload:**

-Snap shot Camera for taking frequent images of the traveler's location for identification of the terrain. The resolution of the camera is a design parameter. It is expected to be in the range which can identify a traveler's camp or a convoy (6-8 m).

Orbit/Constellation Description

The constellation consists of 6-8 small satellites (15-20 kg). The orbits are low earth polar orbits at different planes. The orbits will be designed to allow coverage of all points on earth within 200km of each other at all instances of time.

The orbital computations will be done at the mission design and analysis stage.

Key Performance Parameters

No.	Performance parameter	Parameter	Rationale
1	Number of satellites in constellation	6-8 satellites	Coverage of globe such that at least one satellite is communicable at any instant from any spot on earth
2	Number of satellites visible at any instant from any spot on ground	1	Guarantees that a sent signal will be received by a satellite
3	Ground resolution	6-8 m	Provides a good possibility of identifying location of stranded convoy
4	Prediction algorithm of projected location of stranded convoy		Key parameter-The success of the algorithm is essential to the mission

Research and implementation Problems and challenges:

Some of the research problems envisaged in the project are:

1-Imaging payload for the mission is envisaged to have a snap-shot resolution of 6-8 mt. Can this be carried by a small satellite (15-20 kg)?

2-Algorithm for predicting the next location of the convoy. What is the accuracy? Within how many kilometers?

3-Accuracy of identifying the objects and the terrain.

4-The priority and processing of the data about location and speed…etc. Algorithms for this have to be developed.

5-Communication between the constellation satellites. This is a current research problem in the area of formation flying.

Implementation Plan:

1-Participating Organizations and Project Organization:

The project is expected to be implemented through partnership of several organizations. The project segments and possible participating organizations are listed. The project structure consists of management and system engineering group and several partner groups as follows:

No.	Group	Segment	Team
1	Management	Project management	This is expected to be performed by Cairo University and NARSS (National Authority for Remote Sensing and Space Science in Egypt).
2	System Engineering		Egyptian team-same as above
3	Constellation/Satellite Design	The constellation is either built with a new design or using existing satellite designs of other international partners. There is a need for a partner for this segment. The Egyptian side can participate in design and building the satellite but only partially.	Possibly multiple teams
4	Satellite manufacturing, assembly and test	The satellite is a small satellite weighing 15-20 kg	International Partners-possibly more than one satellite design is used for various satellites of the constellation-This gives a chance for several groups and several countries to participate
5	Payload design and manufacturing	low mass imager (8-10 kg) with a resolution of 6-8 m is needed.	International Partners
6	Ground Segment	Traveler's Transmitter-Receiver and Transmitter-Receiver and storage unit on-board the satellite- Control station and processing software.	Egyptian team + International

2-Time Frame/Project Schedule:

Time frame of implementation from authority to proceed is ~ 2 years. The top level project schedule is as follows:

No.	Activity	Duration
1	Mission analysis and subsystem specifications- Management issues-selection of partners-manufacture vs precure decisions- agreements …etc	4 months
2	Satellite and subsystem design	6 Months
3	Satellite and System Engineering Model	6 Months
4	Components and subsystems manufacturing and testing	4 Months
5	Satellite and ground system space model integration and testing. Launch readiness	4 months
6	Launch opportunity	unknown

3-**Life Cycle of the project:**

No.	Phase	Duration
1	First satellite in Orbit-Experimental	2 Years from authority to design
2	Added satellites	After 1.5 Years (3.5 years from inception)
3	Satellite design lifetime	5 years
4	2 satellites replaced every two years	
5	No of satellites in orbit at any given time	6

4-Project Cost Estimates:

No.	**Item**	**Estimated Cost ($)**
	Management, System Eng.	1,000,000
	Satellite and ground system Design	1,500,000
	Manufacturing & components 2 satellites	2,000,000
	Assembly and Test 2 Satellites	500,000
	Launch	-
	Ground Segment	1,000,000
	Total	6,000 ,000

6-Project Risks and mitigation:

No.	**Risk**	**Mitigation**
1	Unavailability of small weight high resolution imagers	Use lower resolution imagers and adjust locating algorithm accordingly
2	Locating and predicting algorithm	Improve algorithm
3	Inability to identify convoys using available resolution	Send more information about site-use offline higher resolution images or area
4	Satellite weight increases due to imager	Allow slight increase in satellite weight