eLocust3
Desert Locust survey and control data recording and transmission by satellite in real time

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November 2014

Overview

eLocust data represents the foundation of FAO's Desert Locust early warning system - the oldest migratory pest monitoring and early warning system in the world. The data are used for assessing the current situation, forecasting its developments and planning an effective response at all levels.

All frontline countries affected by Desert Locust have a centralized national locust control centre (NLCC) within their Plant Protection Department in the Ministry of Agriculture that is responsible for monitoring their territory through regular field surveys and undertaking control operations when required. eLocust2 is the *de facto* system used by national survey and control officers in all locust-affected countries for recording field observations during survey and control operations and transmitting data by satellite in real time to NLCCs and the Desert Locust Information Service (DLIS) at FAO Headquarters. DLIS maintains a global perspective and is responsible for monitoring habitat conditions and locust infestations on a 24/7 basis from West Africa to India. Since 1975, DLIS has been keeping countries informed by issuing monthly bulletins that summarize the current situation and forecasts developments six weeks in advance. The Bulletins are supplemented by updates, alerts and warnings so that affected countries and international donors have time to respond in an effective manner in order to prevent Desert Locust plagues. The latest technologies (email, Internet, social media) are used for this purpose.

The handheld eLocust unit transmits data by Inmarsat to the respective NLCC via the service provider, NOVACOM, in Toulouse, France. The data arrives at the NLCC by email within a matter of minutes after transmission. eLocust data for the previous 24 hours are collated into a single file that is sent by email to NLCCs in the early hours of every morning. The data are imported into a custom geographic information system (RAMSES) used by each NLCC. At least one nationally designated locust information officer is responsible for managing and analyzing the field data, preparing maps of the locust situation and issuing monthly bulletins. They also export the data from RAMSES and immediately send it by email to FAO DLIS. In Rome, the data are checked and corrected before importing into a custom global GIS (SWARMS) that is used to analyze the field data in combination with satellite imagery indicating rainfall and green vegetation, locust development and trajectory models, and historical records dating from 1930 to assess the current situation and forecast the location timing and scale of locust breeding and migration.

The current eLocust2 system was developed in 2005 by FAO and NOVACOM, the commercial branch of the French Space Agency CNES. This was preceded by an initial proof-of-concept system in 2000. At that time, eLocust2 was a significant advancement because, for the first time in history, decision-makers had access to real time data from some of the remotest areas on Earth thanks to data transmission via satellite. They could also monitor the position and work of the field teams. Furthermore, countries could easily manage large volumes of data associated with increased locust activity without the need to recruit additional staff. Nevertheless, a number of shortcomings became apparent over time such as hardware and software obsolescence, inadequate cables, no battery or GPS, non-expandable memory, a lack of Arabic, mapping, photographic and upgrading capabilities, and limited ability to record all the required data collected during survey and control operations in the field. The objective of the eLocust2 upgrade to eLocust3 was to address and resolve all of these shortcomings.

The hardware of the system was upgraded to the latest commercially available Android OS rugged 10.1 inch handheld tablet, Panasonic ToughPad FZ-A1. The tablet is completely sealed so that dust and water cannot penetrate its components. The display is the best available (late 2012) in terms of readability under bright outdoor conditions common during Desert Locust field operations. The tablet also addresses other shortcomings of the smaller eLocust2 Wescor tablet in that it contains a rechargeable battery, USB connection, external storage (micro SD card), built-in GPS, camera and video, and connection to external monitors or projection equipment (for training) as well as possibility for a SIM card. The tablet is a fully operational handheld computer, which extends its versatility and usefulness, and will provide sufficient flexibility to meet future requirements and needs for at least the next decade.

The tablet uses the Android operating system, which experts claim is the most adaptable system for tablet hardware and allows for greater innovation and expansion. The eLocust3 software has been completely rewritten in Java programming language. Up to 50% more weather, habitat, locust, control and environmental safety data can be recorded and transmitted by eLocust3 compared to eLocust2. Despite this, transmission costs remain the same as for eLocust2. The application is available in three languages (English, French, and Arabic); whereas, eLocust2 was only in English and French. The application is linked to two separate applications, Adobe Reader and eLocust3 3D. Adobe Reader is used for accessing a wealth of reference material (FAO Desert Locust Guidelines, Standard Operating Procedures, vegetation and locust ID cards, equipment manuals, etc.) in the three languages that users may need to refer to while in the field during survey and control operations. Locust officers now have access to a multilingual digital library while in the field.

elocust3 3D is a custom open source map application that guides users to specific areas where vegetation may be green. The latest high-resolution (250m) MODIS-derived dynamic greenness map as well as the latest satellite-based rainfall map can be displayed on top of a static background map such as a Landsat image or a road map. The position of the user is indicated on the map and is updated when moving in the field. Multi-touches are used to zoom in/out and title the image similar to Google Earth. The application is revolutionary because it does not require an Internet connection. It is extremely powerful yet very easy to use. eLocust3 3D is an example of adopting the latest cutting edge technology for use in the developing world. The application was developed for FAO at no-cost by Trilogis S.r.L. (Italy) and incorporates NASA's World Wind technology.

The eLocust3 application allows users to take photos at the location of the survey or control operation that are automatically geo-referenced and can be accessible on the Internet. Photos of habitat conditions and locust infestations are a very good method of supplementing field observations and data.

The eLocust3 system addresses another major shortcoming of the eLocust2 system, that is, the number of cables required to connect the hardware devices. This has been achieved by utilizing Bluetooth (BT) technology to connect the tablet to the antenna for data transmission in real time by satellite. Consequently, only one cable is utilized that powers the antenna from the vehicle cigarette lighter plug. This cable includes a BT adaptor. The antenna itself no longer must sit atop the vehicle but can reside discreetly inside on the dashboard.

The eLocust3 system improves the quality and completeness of data recorded and transmitted by the tablet. This is done through a complex set of logic checks and mandatory data fields that must be realised before data can actually be transmitted by satellite.

The eLocust3 system is compatible with the latest generation of INMARSAT telecommunication satellites that were launched last year; whereas, eLocust2 was incompatible. This means that eLocust2 will cease to transmit data after 2014 when the previous generation of satellites are decommissioned. Therefore, it was obligatory to upgrade eLocust2 to eLocust3 in order not to disrupt data flow from the field to national locust centres and FAO. Data transmission has been improved substantially under the latest

INMARSAT satellite and, as a result, very little data are lost or corrupted during transmission compared to the previous satellite.

There are a number of very sophisticated technologies that have been incorporated into eLocust3. Many of these technologies were just released and had not been utilized before by FAO or locust-affected countries. Therefore, considerable time was required to identify and to become familiar with these technologies, formulate them into the project, incorporate them into eLocust3, and test and validate each component under real field conditions before the development phase of the project could be concluded. It was not possible to indicate all of the technologies and associated requirements at the beginning of the project prior to the programming phase. Consequently, development and testing took longer than originally anticipated at the onset. A more flexible approach was partially adopted that allowed changes to be made during the development and testing phases in order to minimize further delays. This helped to address additional changes that locust-affected countries requested at the last moment and to resolve new issues that appeared during the testing of the software and hardware. NOVACOM delivered a prototype version to DLIS in month 6, followed by more than a dozen beta versions that were tested over the next eight months in Rome and in several countries under field conditions to obtain feedback from potential users. Although these factors delayed delivery of the final product, it did result in an exceptionally good and fully tested final product that should be more robust and reliable, meet the users' needs better, and have a longer operational life.

Phased development

In early 2012, a Desert Locust outbreak developed in Northwest Africa and spread to West Africa. This was an opportunity to address the shortcomings of eLocust2 and upgrade it. Consequently, it was agree that a portion of the emergency funds from FAO and international donors could be used for this purpose since the associated costs exceeding regular programme funding. By the end of the summer, sufficient funding had been obtained to commence the project.

The development project consisted of five distinct phases – preparatory, hardware, software, deployment and training – and lasted just over two years, from 1 June 2012 to 1 July 2014.

During the preparatory phase (152 days), the various options of upgrading eLocust2 were examined, potential funding sources were identified, different hardware, software and transmission possibilities were explored and, finally, the hardware manufacturer and software developer were selected. Most of the time was spent on examining, exploring and testing various options before making the final decision.

During the hardware phase (193 days), DLIS first evaluated all rugged tablets that were commercially available in late 2012 on their processor, memory, storage, display, size, battery, camera, GPS, communications, and ports. From the initial screening, several tablets were selected that met the minimum requirements and manufacturers provided DLIS with evaluation models[1]. This allowed DLIS to test the hardware under field conditions with users in Sudan, India, and Libya prior to the procurement process (tender, order and delivery). The final selection, a Panasonic ToughPad FZ-A1, was based on its outdoor readability, ruggedness, and brand name. The evaluation and testing portion of the hardware phase lasted nearly two months while it took 168 days to complete the procurement process.

During the software phase (571 days), the developer NOVACOM was contracted (42 days), version 1 (303 days) and version 2 (145 days) of the custom eLocust3 software was coded.

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[1] Processor: 1GHz, memory RAM: 1 GB; storage: 16GB flash; Keyboard: on screen; OS: Android 4.x; Display: 10 inch, multi-touch input, outdoor readable; Weight: 1.0kg or less; Size: 28x2x22cm or less; IP index: IP65; Temp: +60C; Battery: 3.7Ah rechargeable Li-ion; Battery life: 9 hours or more; Camera: 5MP (with video); GPS: built-in; Compass: built-in; Communications: WIFI (b/g/n), Bluetooth (2.1), GSM; Ports (for satellite connectivity): USB, Serial RS232 (optional); Charging: vehicle, AC.

NOVACOM was the preferred developer because of their experience with eLocust2, knowledge of the FAO Desert Locust early warning system and, and service provider for data transmission. This experience and familiarity helped to shorten development time and cost. Throughout the development process, DLIS work closely with NOVACOM to identify and refine the data structure and user interface of eLocust3 based on the requirements of the locusts countries and DLIS. The time spent on testing the custom software and NOVASAT Bluetooth antenna cable was equivalent to half the time spent on programming and coding. Once all remaining bugs were resolved, the final version, eLocust3v25, was delivered on 2 June 2014.

During the deployment phase (118 days), the 375 tablets were pre-configured at FAO in DLIS (30 days) prior to distribution to countries by FAO pouch and DHL. Panasonic provided an engineer, equipment and procedures for batch configuration of the units. The units were distributed first to the Master trainers in each country, followed by country quotas prioritized according to countries who will be first using eLocust3 in the summer, followed by those countries who will start using it after the summer. While it took only a few days for the units to reach the countries, it often took up to several weeks or more for the units to be cleared by customs and delivered to the national locust centre.

During the training phase (120 days), DLIS prepared training videos in English, French and Arabic on the various software and hardware aspects of eLocust3. DLIS conducted an inter-regional workshop to train national Master trainers so they can provide training to the end-users, that is, the national locust officers in their country.

Benefits to member countries

The eLocust system represents a major benefit to all member countries, regardless if they are locust frontline or invasion countries. The system allows data collection, recording and transmission from the field to analysts, forecasters, and decision makers in real time. This is critical when managing a migratory pest such as the Desert Locust that can increase nearly 20-fold every three months and migrate 100-150 km per day and quickly cross continents and oceans. The eLocust system will be used mainly in frontline countries but can be dispatched rapidly to other countries during invasion periods and emergencies.

The upgrade to eLocust3 represents yet another milestone. It extends the system's utility by incorporating the three main languages used by locust-affected countries. It improves the quality of the data recorded and its reliable transmission. Photos and videos can be taken to accompany the data and field observations. Additional applications are integrated in eLocust3 to extend its functionality such as guiding survey teams to green vegetation in the field and accessing important references while in the field.

Data recorded and transmitted by eLocust3 are the basis for early warning and preventive control, the strategies adopted by countries and FAO to manage Desert Locust and reduce the frequency, intensity and duration of upsurges and plagues. The eLocust3 upgrade will certainly lead to improved survey and control operations and early warning, thus protecting agriculture, livelihoods and food security.

Distribution and Training

Before eLocust3 could be distributed to locust-affected countries, each unit was pre-configured by AGPMM/DLIS at FAO Headquarters.

CLCPRO W+NW Africa		**CRC** E+NE Africa, Arabia		**SWAC** SW Asia		
Algeria	20	Djibouti	0	India	35	
Burkina Faso	2	Egypt	20	Iran	11	
Chad	16	Eritrea	14	Pakistan	30	
Libya	13	Ethiopia	6			
Mali	15	Oman	11			
Mauritania	31	Saudi Arabia	20			
Morocco	20	Somalia	2			
Niger	21	Sudan	25			
Senegal	2	Yemen	15			
Tunisia	2	DLCO-EA	2			
subtotal	**142**		**115**		**76**	**333**
stock						45
total						**375**

DLIS developed self-training materials such as videos, presentations, slideshows and fact sheets distributed through social media (YouTube, Slideshare, Facebook). The training material was translated into French and Arabic.

eLocust3 training was a two-step process. In the first step, three FAO trainers trained 17 national locust information officers as Master Trainers in English, French and Arabic at an inter-regional workshop in May 2014 (Agadir, Morocco). The training concentrated on the use of the tablet, applications and peripheral devices, general hardware and software maintenance, care and troubleshooting in resolving problems as well as how to train users. During the summer, the national Master Trainers will train national survey and control officers in their respective countries who will be using eLocust3. In this way, eLocust3 will be operational in all locust-affected countries in summer of 2014.

Sustainability

All efforts are made to sustain the routine operation, maintenance and training of eLocust3. The trust funds of the FAO regional locust commissions in the western (CLCPRO), central (CRC) and South-West Asia (SWAC) regions cover the data transmission costs as well as minor support costs. Additional financial mechanisms will be identified to cover any additional costs associated with future updates of eLocust3 to extend its functionality as well as support and further development to the custom national geographic information system, RAMSES, used in each country to manage eLocust3 data.

FAO DLIS would like to ensure further sustainability of the global early warning system by migrating all custom applications and GIS to open standard, open-source and to take full advantage of NASA's World Wind technology. So far, a few initial steps have been taken. Work is under way to redesign RAMSES GIS, shifting it from ESRI ArcView and Microsoft Access to Open Jump and PostGIS. The eLocust3D application uses NASA World Wind. Further efforts are required to migrate SWARMS GIS from ArcGIS to open source and to integrate all of the various systems into a single open standard, open source LocustGIS4D for use at the national, regional and global level that would benefit all stakeholders. For this to become a reality, extra-budgetary funds will need to be identified for 2015-2017.

Publicity

The eLocust3 3D application was featured on an Italian news broadcast, LA7, in January 2014. The eLocust3 system was highlighted as a segment in the prime-time science programme SuperQuark (http://www.superquark.rai.it) on Italian TV (July 2014). Panasonic is preparing a business case for eLocust3. National Geographic magazine has indicated interest in featuring FAO's Desert Locust early warning system including eLocust3 in an upcoming article. eLocust3 3D was a co-winner of the 2014 World Wind Europa Challenge

(http://eurochallenge.como.polimi.it/) sponsored by NASA. It was also presented at the international conference on Big Data from Space sponsored by European Space Agency in November 2014.

Further information

FAO Desert Locust early warning system – LocustWatch
www.fao.org/ag/locusts
www.facebook.com/faolocusts
www.twitter.com/faolocust
www.slideshare.net/faolocust

eLocust3 training videos
www.youtube.com/playlist?list=PLjxRk5CAwvG_0iFxjZ5C2fLByF3jhvHOx

eLocust3 Master Trainers workshop
http://www.slideshare.net/FAOLocust/2014-clcprocrcswac-desert-locust-information-officer-workshop

eLocust3 3D (Trilogis Srl)
http://www.trilogis.it/eLocust3D/

Panasonic ToughPad
http://www.panasonic.com/business/toughpad/us/best-android-rugged-tablet-overview.asp

NASA World Wind
http://goworldwind.org

Rainfall estimates and greenness maps (IRI, Columbia University)
http://iridl.ldeo.columbia.edu/maproom/Food_Security/Locusts/

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