The following PDF as well as the attached Youtube link were the basis for the presentation at the Drones Applied to Geophysical Mapping Post Conference Workshop at the SEG annual meeting in September 2017, Houston, TX, USA. The actual presentation cannot be published at this time.

YouTube link to the video from CNBC

https://youtu.be/mp-9-mXny58
Imagine a swarm of drones hovering over a remote tropical forest dropping what looks like large darts. The darts are actually seismic receivers delivered from the air as shown in an animated video from Total. They are part of a project to totally rethink how surveys are done in remote spots where the jagged landscape limits movement on the ground.

The goal is to find ways to sharply reduce both the cost and the environmental impact of gathering the volumes of data needed to illuminate oil and gas deposits in complex, hard-to-image formations.

Their testing ground, Papua New Guinea, is a perfect example of the problem. Florent Bertini, Earth Imaging R&D Program Director at Total, describes it as “one of the most challenging places on Earth for seismic acquisition.” And there are enough other locations where the barriers to generating the booming sounds needed for seismic and recording how it reflects off the layers below are great enough to justify taking on some extreme technical challenges.

“Tomorrow’s most promising onshore oil and gas exploration acreages are located in foothills, yet these areas have been underexplored as traditional exploration methods not suitable to deal with these complex environments,” Total says in the video.

Rather than hacking paths through dense forests to set out lines of seismic receivers, they are building and testing a system using drones to drop thousands of receivers that will biodegrade after the survey.

A lead drone will coordinate the flight. It will ensure the drones remain safely above the tree tops. And it will control each DART drop, using an infrared scanning system to ensure there are no large animals below before ordering the release, Total said.

A radio communication system developed by Wireless Seismic, called the Downfall Air Receiver Technology (DART) links the DARTs to a control and processing center that monitors the quality of incoming data and makes changes if there are problems.

Total said the rewards justify some tall technical challenges.

“Poor accessibility remains the largest challenge for seismic programs in these settings, which drives up cost, time, and HSE exposure,” Total said.

Frontier Technology
The current version of the system will be tested later this year when a single drone will be used to drop 100 of the DARTs...
over a 0.2 km² area. That will show if a new carousel on the underside of the drone, which carries four darts, can drop them one at a time at locations along its route.

They will also see how reliably the DARTS can record and transmit data. This will require landing them in a nearly vertical position for reliable data gathering, and then transmitting the information to a central processing center.

The drone test is the next step in a project that began in 2014 to develop the multiphysics exploration technology integrated system (METIS). Total is building toward an “industrial-scale” pilot project, which it hopes will be ready in 2021, where to deploy 40,000 to 50,000 DARTs over a 100 km² area, said Bertini.

The partners need to prove that they can efficiently and safely deliver darts on the scale required to gather a large volume of data over a wide area that is required for the advanced imaging methods. Current survey methods often result in ambiguous images for those interpreting them.

**Airborne Delivery**

Automated drone flights carpeting the forest floor are just one of the aerial departures from conventional ground-based, data-acquisition methods.

To move in heavy loads without a road or runway, Total is working with a French company with an apt name, Flying Whales, to develop a new airship, called the HA2t. The name of the 40-ton blimp stands for hybrid air, 2 tons, which will allow it to bring in buildings for the operations center. It is designed to be packed inside a standard shipping container for rapid delivery around the world.

Before any heavy equipment arrives, data from satellite imaging and aircraft surveys using a variety of methods—hyperspectral, radar, and LiDAR (Light Detection and Ranging)—are used to create detailed maps of the surface and near surface. Those will be used to choose the best locations for seismic sound sources and receivers, and plan how best to manage the operation.

Airborne surveys will be used to determine the height of the tree tops—drones are generally expected to fly about 20 m above them. They will also be seeking openings in the forest canopy, which Bertini calls “sky holes.” These natural openings would reduce the cost and impact of creating clearings for an operations center and the sound sources, which cannot be dropped in place. In early testing, the sounds required will come from buried explosive charges.

The third partner in the project, Geokinetics, is designing, acquiring, and processing the data in an environment where the difficult terrain will define the location and number of sound sources and receivers.

Technically speaking, good imaging of complex rock requires high trace density. That is a measure of the quality of the subsurface illumination, which is a function of the number of seismic sources and receivers. More receivers can compensate for fewer sound sources, and vice versa. And they must be evenly distributed to ensure the entire area is covered. Adding receivers is likely to be the best option for increasing the trace density.

“By adopting a carpet receiver approach, where receiver stations are located on average 50 m in all directions, METIS reduces the dense source requirement” by using more receivers, Bertini said.

“In foothills environment, currently available source technology is significantly more costly, dangerous, and
damaging to the environment than deploying additional receivers,” he said.

To verify the system is delivering the required quality and quantity of data, the communication system will provide real-time data, which will be analyzed to create preliminary images. Those will be used to ensure the quality of the data and to seek out any gaps, which could include further DART drops.

**Innovation Required**

Keeping the work off the ground, and minimizing the impact when it does touch down, will require significant advances.

For the same reason the company needs to avoid placing receivers it wants to be able to avoid collecting them afterward, Bertini said such an operation would require as many as 1,000 people for the 100 km² pilot test. Their solution is for the DARTs to biodegrade after the survey is done. The DART case is already made of biodegradable material, and the company is working on finding ways to mass produce batteries and sensors that fade away.

Bertini said it has identified likely solutions. Total has made significant investment in projects to develop bioplastics and recently bought a battery company called Saft that has expertise in that area.

There are ways to make a biodegradable circuit board. Bertini said adapting those methods to create seismic components will “take significant effort.” And while there are prototype biodegradable batteries, more development is needed for full-scale field application.

To get more out of each DART, the company is working to extend the battery life, with a goal of 21 to 28 days of recording time. To conserve power, the devices can be turned off by a signal from the central data recorder when not needed.

And there is a plan to change the sensors to eliminate the need to stick the landing. For the upcoming test, the pointed DARTs will need to be standing within 15° of true vertical to record good quality seismic data. The company is working on replacing the geophone with multidirectional accelerometers (3-axis MEMS) that are smaller, lighter, and can record a wider range of data, even if the DART is not upright.

Total is also looking for an alternative to explosive sound sources that can be delivered to difficult-to-reach spots. It will also be dealing with a nontechnical issue—the likely reactions if people living on the ground begin seeing DARTs around them.

“There is clearly a cultural challenge to be handled at a very early stage of any kind of operation (seismic, drilling, etc.) in any foreign country, more particularly where cultural or education differences are high,” he said, adding: “For such specific challenges, we have in Total and in our partners teams, some highly skilled professionals used to dealing with socialization and technical education of local populations” working with the staff in those areas. **JPT**

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![LiDAR data are used to map the contours of the survey area during the planning process. Source: Total.](image-url)