

# ID35 - RIPPLES: A TOOL FOR SUPERVISION AND CONTROL OF REMOTE ASSETS

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## Abstract

We describe the Ripples cloud-based software for coordination and control of multiple remote assets. Ripples can ingest and disseminate data coming from multiple sources such as physical models, drifting sensors, marine traffic (AIS) and unmanned vehicles deployed in remote areas. On top of data dissemination and awareness, Ripples can also be used for planning the autonomous assets using satellite communications, maintaining the operators in the loop.

*Keywords – Autonomous Vehicles, Ocean Observation Systems, Remote Sensing*

## I. INTRODUCTION

There are many scientific applications that require synoptic observations over large remote areas, such as physical oceanography or marine biology.

In this paper, we present a new tool developed to help scientists have a better grasp of these large-scale phenomena using remote sensing data, autonomous vehicles, marine traffic and other in-situ sensors. Ripples, is a cloud-based software that can ingest data from multiple sources and control multiple distributed assets over low-bandwidth and high latency communications such as satellite.

## II. IMPLEMENTATION

Ripples extends the existing LSTS Toolchain [1] as a centralized hub that concentrates and disseminates information between remote locations. Ripples provides multiple entry points to which data can be fed:

1. ARGO floats: receives data from thousands of drifters already deployed in the ocean [2];
2. FindMeSpot: receives real-time positions from SPOTTracker devices which are associated with known assets such as ships or unmanned vehicles;
3. AIS: can ingest data from different providers such as AISHub and Marine Traffic;
4. Neptus: can ingest real-time data pushed over the web (Web Sockets) from Neptus C4I software, part of LSTS Toolchain;
5. DeviceState: Device states (position and readings) can be pushed from any device connected to the web directly, or indirectly (e.g. using a web gateway);
6. Iridium: Ripples also supports data pushed over Iridium satellite communications. Namely it can listen to short burst data (SBD) from RockBlock.

The previous entry points all generate data points in a timeseries database of positions and measurements. These data can be queried also via several REST services using JSON and CSV formats. The JSON format is especially useful for

web clients as it can be easily parsed in JavaScript and displayed visually with frameworks such as LeafletJS or OpenLayers.

Ripples is implemented in Java SE and is hosted in the Google Cloud Platform. This is an elastic platform that can grow linearly to the data size and number of users automatically. Google also provides several cached instances of the application which decreases load time across the world. The last state of all devices is also hosted on Google's Firebase, a real-time DB that pushes updates to clients automatically over the web.

## III. SUPERVISION AND CONTROL OF AUTONOMOUS ASSETS

In order to control autonomous assets via Iridium, we consider part of its state the configuration and plan being executed by each autonomous asset. The configuration of each system is a list of key-value pairs which correspond to settings in the device that can be changed after it has been deployed. Examples of such configurations are the vehicle's active payloads, depth and speed to use for planning, etc.

In Ripples, a plan consists of a list of waypoints where the device will be sometime in the future. Each waypoint thus contain a geographical location together with estimated time of arrival. Even though the vehicles may not be travelling in straight lines between waypoints, Ripples assumes that the vehicles will arrive at the waypoints on time and can be contacted using Iridium at those locations. The assumption is possible if conservative speeds are used for planning and the vehicles actively pursue the desired ETAs (by controlling their speed).

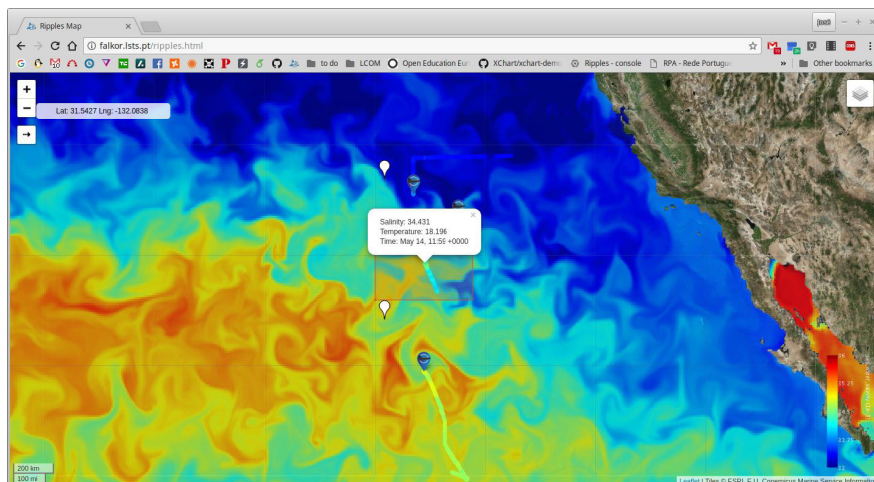
Plans can be received from the operators (using Neptus) or they can also be generated onboard the vehicles (in reaction to dynamic phenomena or failures). In both cases these plans are communicated to Ripples and disseminated to all destinations so that the predicted state of every device can be calculated even while they remain disconnected.

## IV. RESULTS AND CONCLUSIONS

Ripples has been used multiple times to supervise the execution of multiple autonomous vehicles. It is used to monitor the execution of surveys in Douro River while autonomously tracking river plumes and in recently it has been used to control a fleet of autonomous vehicles to map the Pacific's Subtropical Front, 800 miles offshore from San Diego.

## REFERENCES

- [1] J. Pinto, P. S. Dias, R. Martins, J. Fortuna, E. Marques and J. Sousa, "The LSTS toolchain for networked vehicle systems," 2013 MTS/IEEE OCEANS - Bergen, Bergen, 2013.
- [2] Coriolis Operational Oceanography Web Site, Online, <http://www.coriolis.eu.org/Observing-the-Ocean/ARGO>, October 2018.



**Fig 1. Snapshot of a Ripples web client showing real-time data from two autonomous vessels together with CMECS salinity models**