
planet.
OpenLST
An open radio system
Mercator Projection

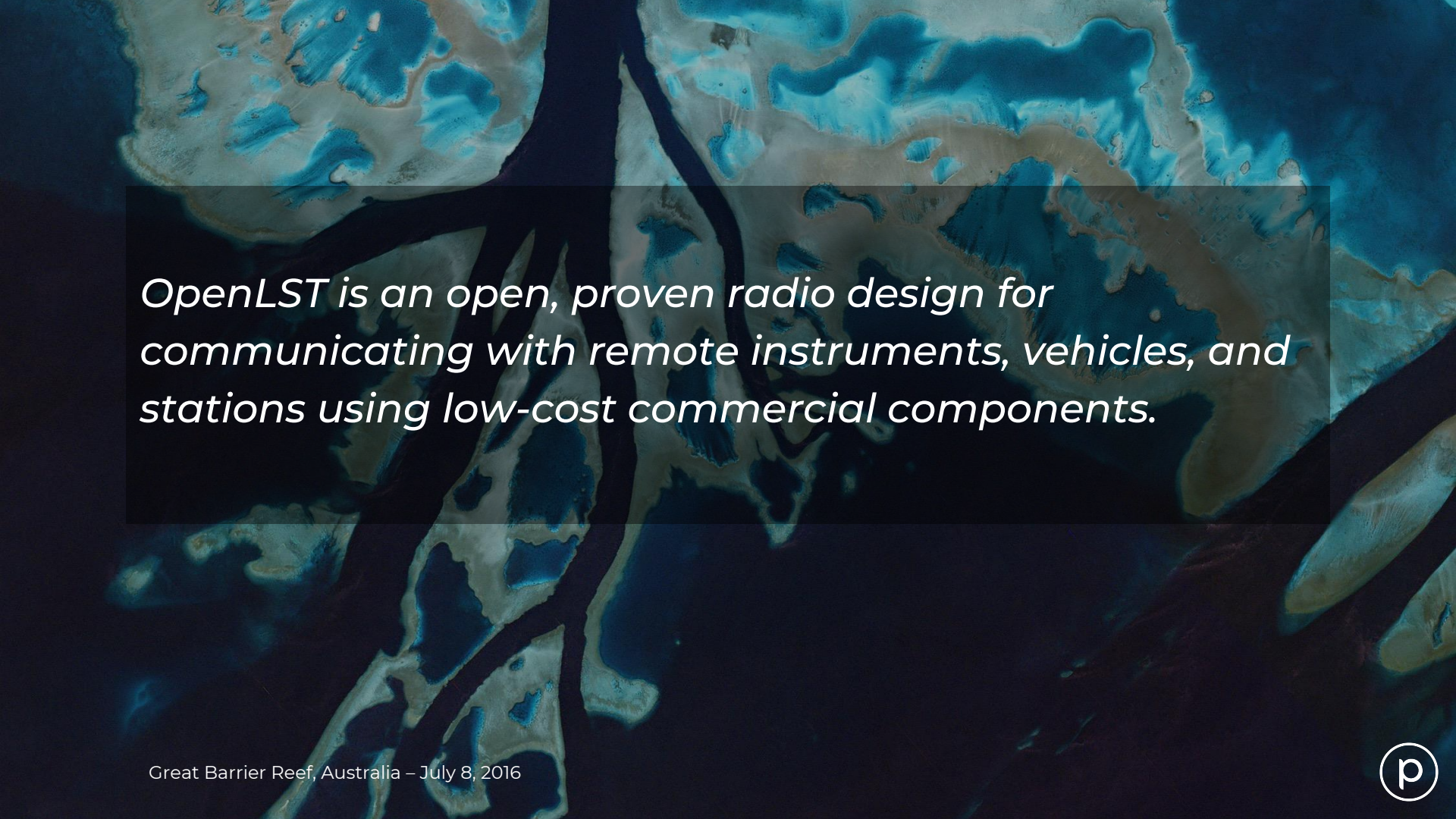
EAR/ITAR

- OpenLST is a static release of a general-use design and software framework for a variety of radio uses.
- It is being published online without restriction, and is not a collaborative platform.
- While inspired by the LST used on Planet's Dove satellites, OpenLST is not directly related to, nor is it a byproduct of, any satellite development.
- **Subsequent designs using OpenLST may be subject to restrictions under the EAR and/or ITAR.**

Disclaimer

The user is responsible for obtaining and maintaining the necessary licensing to operate the radio.

The example project uses frequencies in the US Amateur Radio UHF band. Transmissions in this band require a valid FCC license and compliance with CFR Part 97.



OpenLST is an open, proven radio design for communicating with remote instruments, vehicles, and stations using low-cost commercial components.

Great Barrier Reef, Australia – July 8, 2016

Background

Iguazú National Park, Brazil – September 23, 2016

History

Planet developed the Low-Speed Transceiver (LST) for UHF telemetry, command, and control of the Dove satellite.

Over 100 on-orbit Dove satellites use the LST today.

OpenLST draws on Planet's experience and success with the LST hardware and firmware.

Applications

OpenLST is an open, proven radio design for communicating with remote instruments, vehicles, and stations using low-cost commercial components.

Use Cases

- Remote sensing platforms
- Drones
- High-altitude balloons
- Amateur wireless experimentation
- University/Amateur Satellites

Central Pivot Irrigation, Saudi Arabia

Reliability

Planet has used its LST UHF radio on over 200 Dove satellites. Based on commercial hardware, the LST has several hundred cumulative years of on-orbit operation.

The LST has an outstanding success record (with over 200 cumulative years of on-orbit operations) despite having a component cost of < $50.

Problem Statement

OpenLST is meant to fill a perceived void in current CubeSat design. Many educational projects view communications as prohibitively difficult to design and will buy a COTS radio that may not integrate well with the project or be poorly understood.

Communications subsystems are thought to contribute to at least 29% of CubeSat failures in the first 90 days on-orbit.[1]

1. Martin Langer, Jasper Bouwmeester. Reliability of CubeSats - Statistical Data, Developers' Beliefs and the Way Forward. SmallSat, 2016. SSC16-X-2.

Jeddah, Saudi Arabia

Purpose

OpenLST presents an accessible design based on an existing and proven radio using inexpensive and widely available COTS parts with the goal of encouraging radio experimentation and aiding aspiring engineers and engineering projects.

Release Information

Cancún, Mexico – August 18, 2016

Software / Hardware License

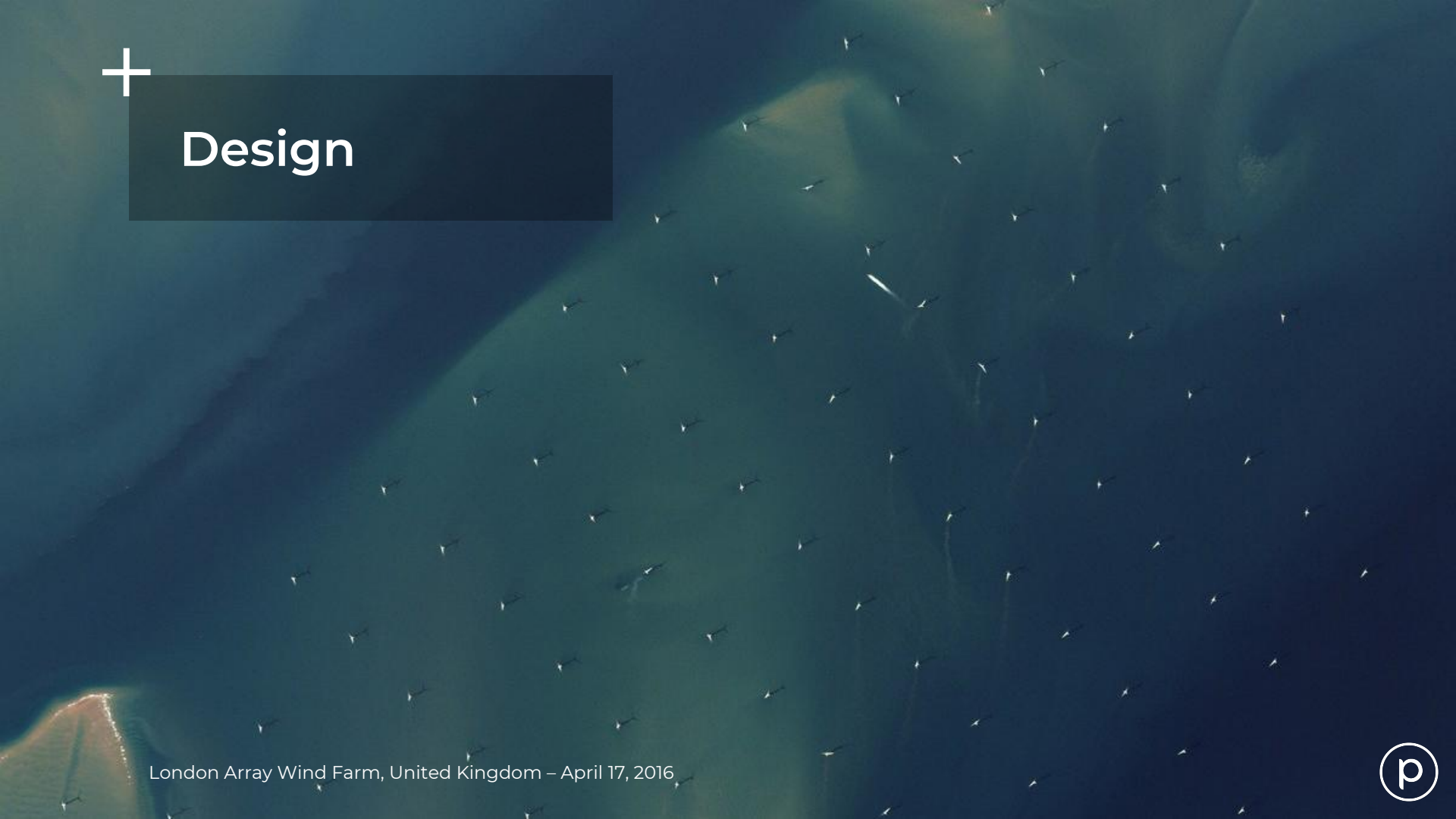
- Code is released under GPLv3

- Hardware is released under Creative Commons ShareAlike (CC-BY-SA 4.0 US)
  - Attribution required
  - ShareAlike - changes or modifications must be released under the same license
    - Specific implementation details (frequencies, modulation, keys, etc.) are exempt.

What's Included

1. A reference hardware implementation
2. Firmware source for a bootloader (over the air updates) and radio application
3. A reference project targeting the 70cm band
4. Python tools for basic testing and operation
5. A user's guide for getting started, programming, and customizing the project

Design



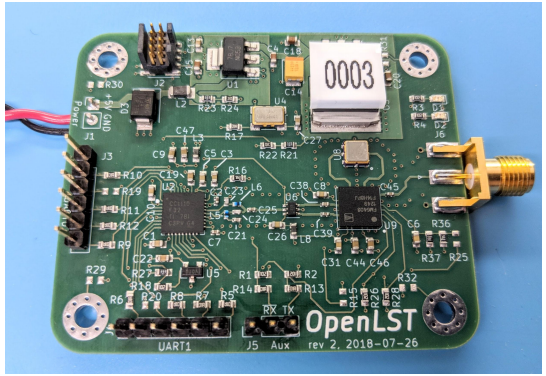
London Array Wind Farm, United Kingdom – April 17, 2016

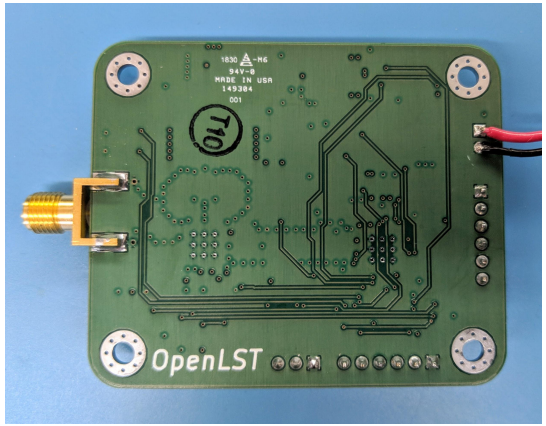
Hardware Overview

- Texas Instruments CC1110
  - 8051 microcontroller w/32 kbyte flash
  - Radio transceiver peripheral
  - UARTs, GPIO, ADC, etc
- OpenLST is a simplified version of the TI CC1110 evaluation board
- Additional 1 watt power amplifier module for extended range

Construction & Prototyping

- Printed Circuit Board (PCB)
  - 4-layer stackup, some microstrip traces
  - We designed to the popular/cheap OshPark 4-layer service stackup.
- Components
  - Most available from mainstream distributors
  - A few specialty items need to be sourced separately: SAW filter, PA module
  - Bill of materials has details
- Assembly
  - All components on top side of board
  - Solder paste stencils from OshStencils
  - Hot air rework tool used to reflow the board



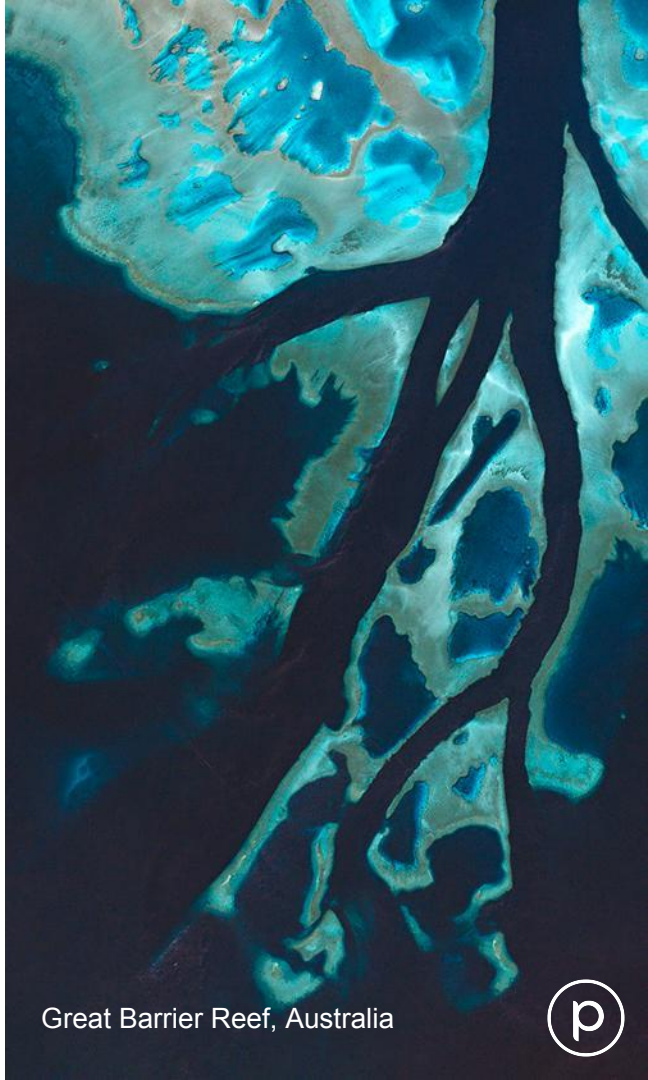


Specifications

Parameter	Value	Notes
Size	6 x 5 x 0.5 cm	Excludes antenna
Mass	20 g	Board with components only
Power Consumption	TX: 8.0 W	5 V at 1.6 A
	RX: 0.8 W	5 V at 160 mA
Frequency	437 MHz	405-475 MHz covered by PA, split frequency operation is possible with firmware mods
RF Transmit Power	1 W (+30 dBm)	Power can be reduced if desired
Receiver Sensitivity	-112 dBm	Minimum detected signal, RF quiet environment
User data rate	3500 bps	Firmware configurable, includes ½ rate FEC
Modulation	2-GFSK	Firmware configurable
Ranging Performance	1 km RMS	Time-of-flight ranging performance
Flash Memory	32 kByte	12 kB currently used

Firmware Overview

- Bootloader
  - Provides over-the-air update function
  - Verifies application code integrity
- Application code
  - Comms with host processor
  - Telemetry: RF statistics, voltages, temp, etc.
  - Time-of-flight ranging
- Compiler: Small Device C Compiler (sdcc)
- 60% of flash memory is available for user features



Getting Started

What You'll Need

1. An evaluation board
   Print your own PCB from the included Gerber files
2. A Texas Instruments CC Debugger tool (~$50) and a DC power supply
3. Appropriate licensing for your jurisdiction to operate test equipment in the 70cm band

User's Guide

- Included Markdown file
- Walks through flashing and bootloading radio firmware via a Vagrant VM
- Includes suggestions for customizing the example project

Included Software

- Radio “mux” program for multiplexing multiple user I/O to the UART (uses ZMQ)
- Radio Terminal program for partially interactive Tx/Rx (based on Curses)
- Flashing, signing, and bootloading tools
- Translator for turning written commands to bytearrays

Get Access

Clone the project from:
https://www.planet.com/open/openlst.git
https://www.planet.com/open/openlst-hw.git

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git clone https://www.planet.com/open/openlst.git

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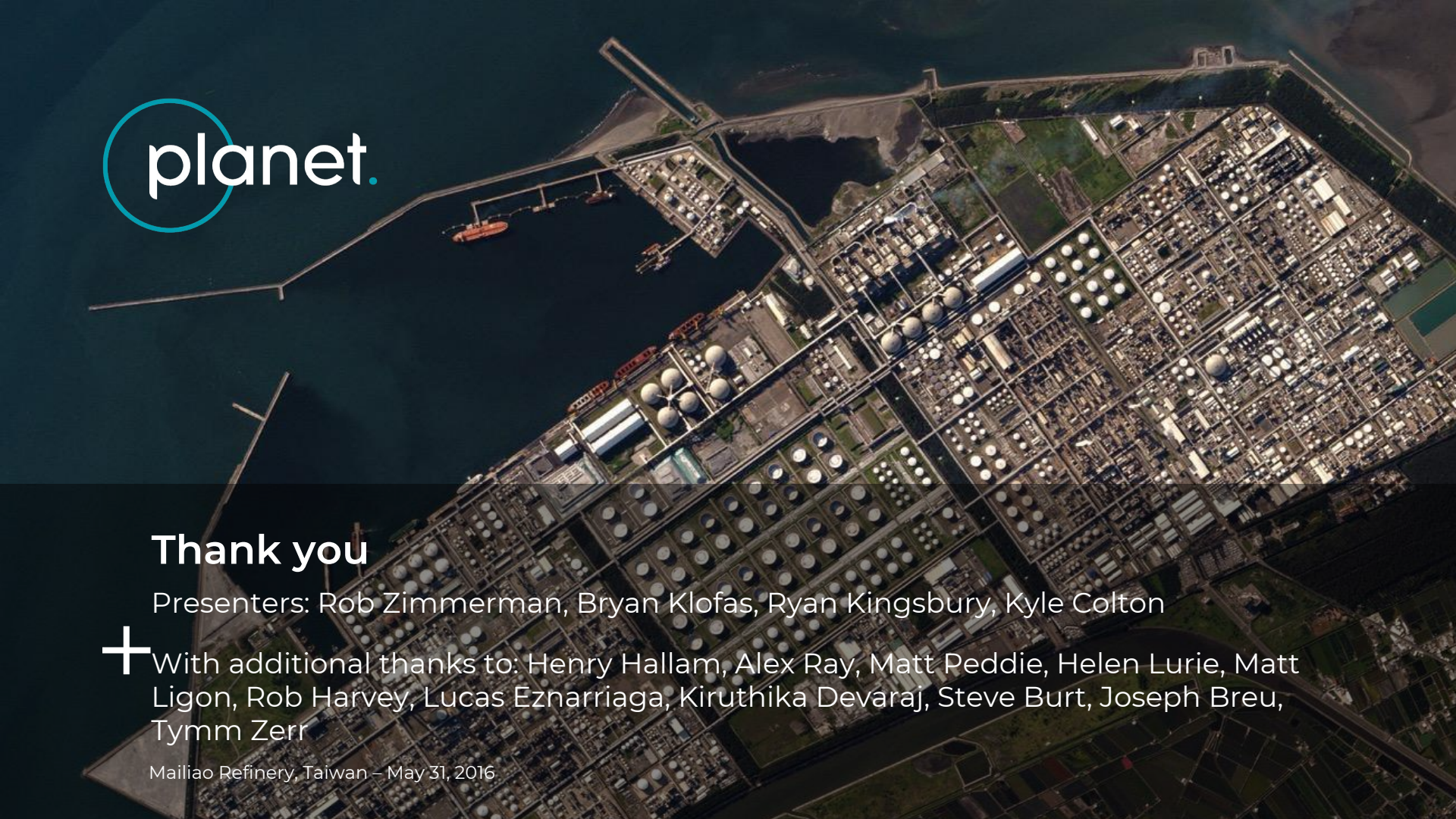

Thank you

Presenters: Rob Zimmerman, Bryan Klofas, Ryan Kingsbury, Kyle Colton

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Mailiao Refinery, Taiwan – May 31, 2016