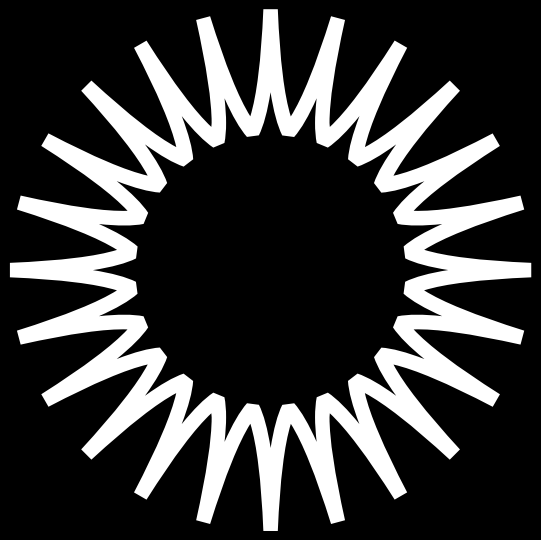

SPUR

Ideas + Action for a Better City

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VTA's Transition to EV bus

SPUR San Jose Forum: Leading the Charge on EV Buses and the Future of Transportation

Gary Miskell, Chief Technology/Innovation Officer
Santa Clara Valley Transportation Authority
October 24, 2018

Santa Clara Valley Transportation Authority

Solutions that move you

Santa Clara Valley Transportation Authority (VTA)

Transit Authority

- 34 million passenger trips per year
- 450 bus, 100 light rail trains, & paratransit
- Funding partner in regional rail service
  Caltrain, Capital Corridor
  Altamont Corridor Express.

Santa Clara congestion management

- Countywide transportation planning
- Design and construction
  highway, pedestrian, and bicycle improvement projects
  transit oriented development.

Solutions that move you

- Proterra battery-electric buses
  - E2 Series with 440 KWH energy capacity
  - Plug-in Charging @ < 4.5 hr. to charge
- The average household in the United States uses about 24 KWH of electricity each day
- VTA ZEB program will help meet ambitious state goal of 1.5 million zero emission vehicles (ZEVs) on California roadways by 2025.

"About 279,000 barrels a day of fuel won't be needed this year due to EV's"
Jeremy Hodges Bloomberg Technology

Standard Diesel

Clean Diesel, Hybrid

Zero Emission Battery Electric Bus (ZEB)

Operate the same way,
Have 80% common parts match
No difference in route planning
Small difference in driving the vehicles
Hybrid brings in new Battery drive train tech.
Taller so it's easier to hit tree branches

Complete technology change
Driver changes
Electrical / Mechanical maintenance
Yard Management changes
Much higher Installation investment
Route limitation
Fueling takes hours

Solutions that move you

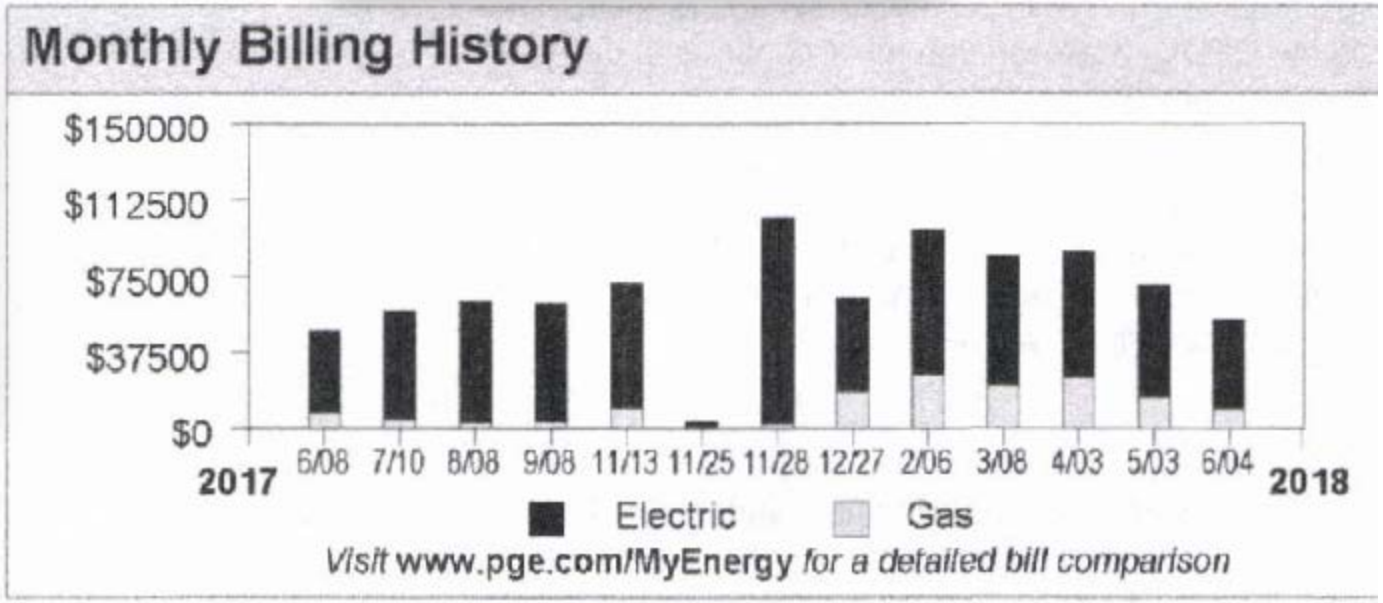
VTA Cerone Yard

Averaging $450K per year

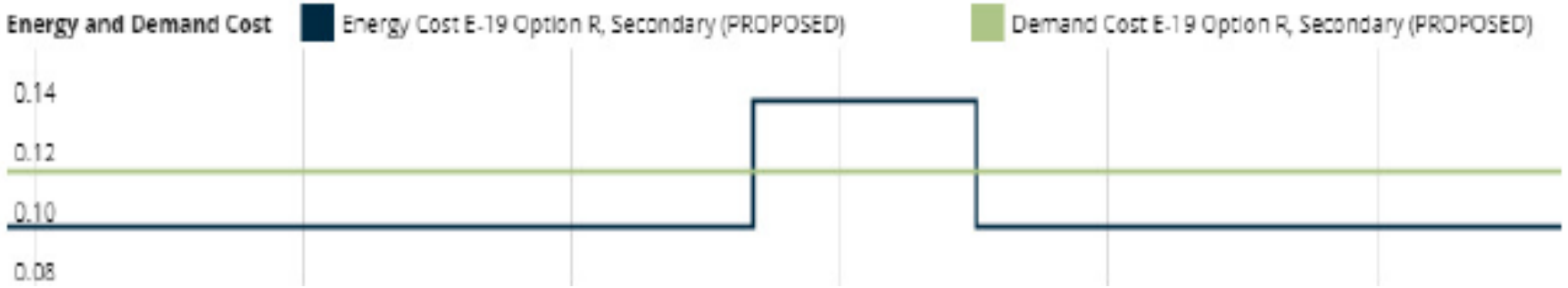
675 KWH Generator
650KWH Generator
1,300 KWH Generator

960 KWH Solar
1200 KWH Solar

Maintenance
Mid Life Overhaul
Operations/Dispatch



6 Smart Chargers
5 Smart Chargers



Electric Buses – Energy Cost

Per EV bus = $7.0K to $10.2K of electricity per year

Depot evening Charging only

First 5	$ 35.0K	$ 51.0K
25 buses	$175.0k	$225.0k

Extended operation with 2 Depot charging cycles

AM run => Mid day charge => PM run => Night Charging

2.1 megawatts of solar installed at three VTA sites

- *Cerone Yard 969 KWH*
- *North Yard 637 KWH*
- *Chaboya Yard 548 KW*

Monitoring the Vehicle for beginning to end

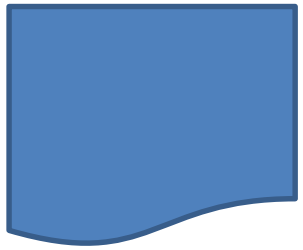
Clever Devices

On board system
- Interfaces to the Vehicle system
- Human Machine Interface HMI

Fleet Schedule / monitoring

Fleet Manager
- Configuration Management
- Service Management
- Performance Management
- Performance History

Business Intelligence & API's
- Reporting
- Data mining
- Integration to other applications



Electric Vehicle Monitoring System (EVMS) will communicate to all systems to report on EV usage and efficiencies.

Solutions that move you

Monitoring the Vehicle

What's Next!

- Charging Strategies and ZEB mileage
  - Now we're seeing 180 Actually want 380 per day
  - Upgrading the chargers to 120KW per hour (early 2019)
    - Ratio of ZEB's to Chargers (direct Infrastructure cost)
  - Mileage between Charges & Battery storage
    - Today 440KWH – Shorter routes & double pullout
    - Future 1,000KWH – run an equivalent long hall route
  - Depot VS In-Field Charging
    - $'s per installation
    - Impact on Batteries
- Emergency Management of a ZEB fleet
  - One thing to deal with 5 to 25
- Energy Management
  - Expanded Solar and Energy Storage

- Next Generation of EV's
  Paratransit & First / last mile

Expanded Solar

Smart Microgrid + Second life Li-Ion Energy Storage

LEHIGH UNIVERSITY

Solutions that move you

Zero Emissions Bus Vehicle to Grid Integration Project

SPUR San Jose Form
October 24, 2018
Mike Harrigan, Program Manager
Prospect Silicon Valley

PROSPECT
Silicon Valley

VTA Advanced VGI Project

Agenda

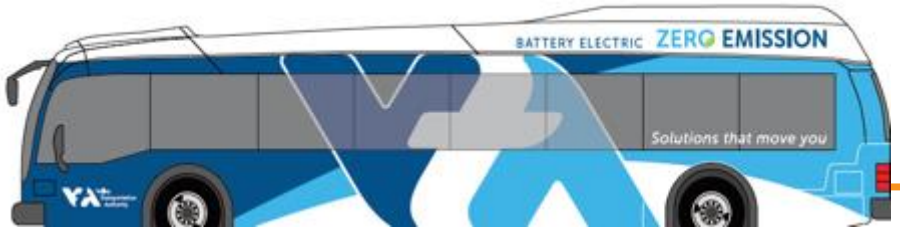
- Summary
- Project Team
- Overall Project Goals
- Energy Management Platform Goals
- System Architecture and Data Flow
- Physical Infrastructure
- Technical Innovation

Summary

One of two first transit bus vehicle – grid integration projects in the US

- CEC grant and match funded
- Advanced energy management & services for 5 – 35 electric buses
- State-wide scaling analysis
- Project Term: 6/1/17 - 4/30/21
- Grant: $1.9M
- ProspectSV is project lead

The second CEC funded bus project is e-Bus to Grid Integration by the Antelope Valley Transit Authority. Similar in objectives, different in approach. We are actively collaborating with that team.



Project Team

	Partner	Team	Role
	California Energy Commission	Commission Agreement Manager: Bryan Lee	Funder
	VTA	Gary Miskell - CIO Manjit Chopra - Project Manager Joonie Tolosa – Operations, Content Expert Jim Wilhelm – Engineering	Project host, end user/owner, operations integration
	Proterra	Rajiv Singhal - Head of IOT/SaaS	Delivery of Zero Emission E-buses Technology integration and consultation
	Kisensum	Paul Lipkin – Co Founder	Energy controls software
	National Renewable Energy Lab (NREL)	Joshua Eichman – Research Analyst	Analysis, Modeling, Measurement & Verification
	Prospect Silicon Valley	Venkatesh Nadamuni – Project Manager Mike Harrigan – Content Expert	Strategic management, best-practices, commercialization
	Charge Point	Kevin Doyle – Product manager Ben Wexler – Application Engineer	Technology Integration for Chargers
	Energy Solutions	Tamara Perry – Sr. Project Manager Andrea Vaz – Quality Assurance Specialist	Communications consultation, state recommendations, Quality Assurance
	Calstart	Jasna Tomic – Research Director	Knowledge Transfer
	NOVA	Luther Jackson – Program manager	Support stakeholder education
	Clever Devices	Saundra Graman - VP Dean Roussinos – Product Manager	VTA Software supplier - Realtime Telematics and business intelligence
	Trapeze	Bill Boston – Product Manager	VTA Software supplier – Fleet Route management

Project Goals

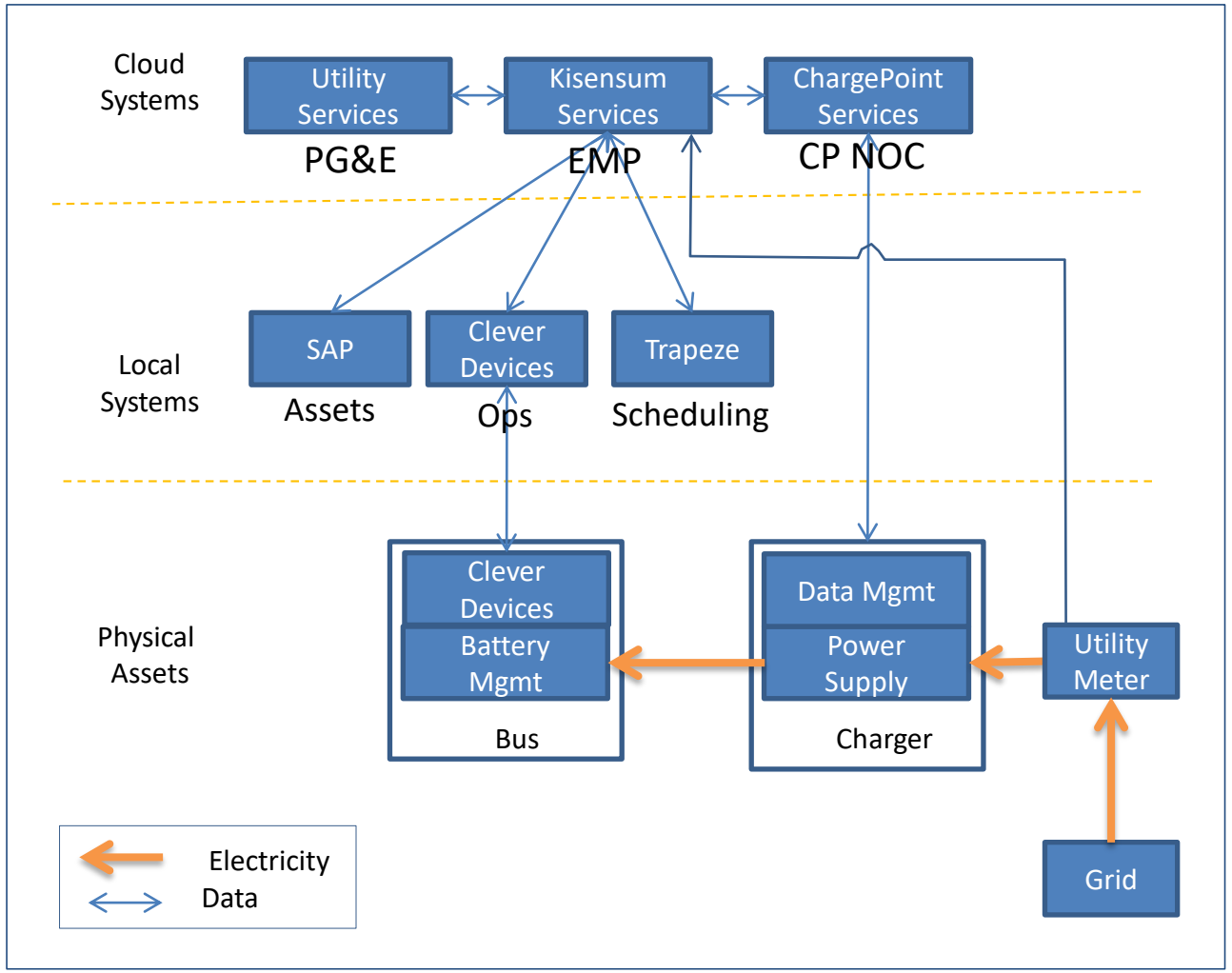
Goals	Benefit
1. Develop Advanced Energy Management and Pilot Revenue Generating “Grid Services”	Lower Energy costs Minimize Impact on Grid
2. Develop analytic and implementation roadmap for VTA (and California)	Inform planning & Future e-bus implementations
3. Support for Operations process revisions	EV readiness
4. Support Accelerated Commercialization and Readiness (incl. stakeholder education, training, integration)	Better integration and support

Energy Management Platform Goals

1. Ensure that the buses are charged and ready to go before pullout time
2. Provide visibility into charging process
3. Send alerts when there are issues in the charging process that need to be addressed
4. Support the bus to block assignment process
5. Minimize PG&E bill
6. Simulate Grid interactions with system

Architecture Strategy

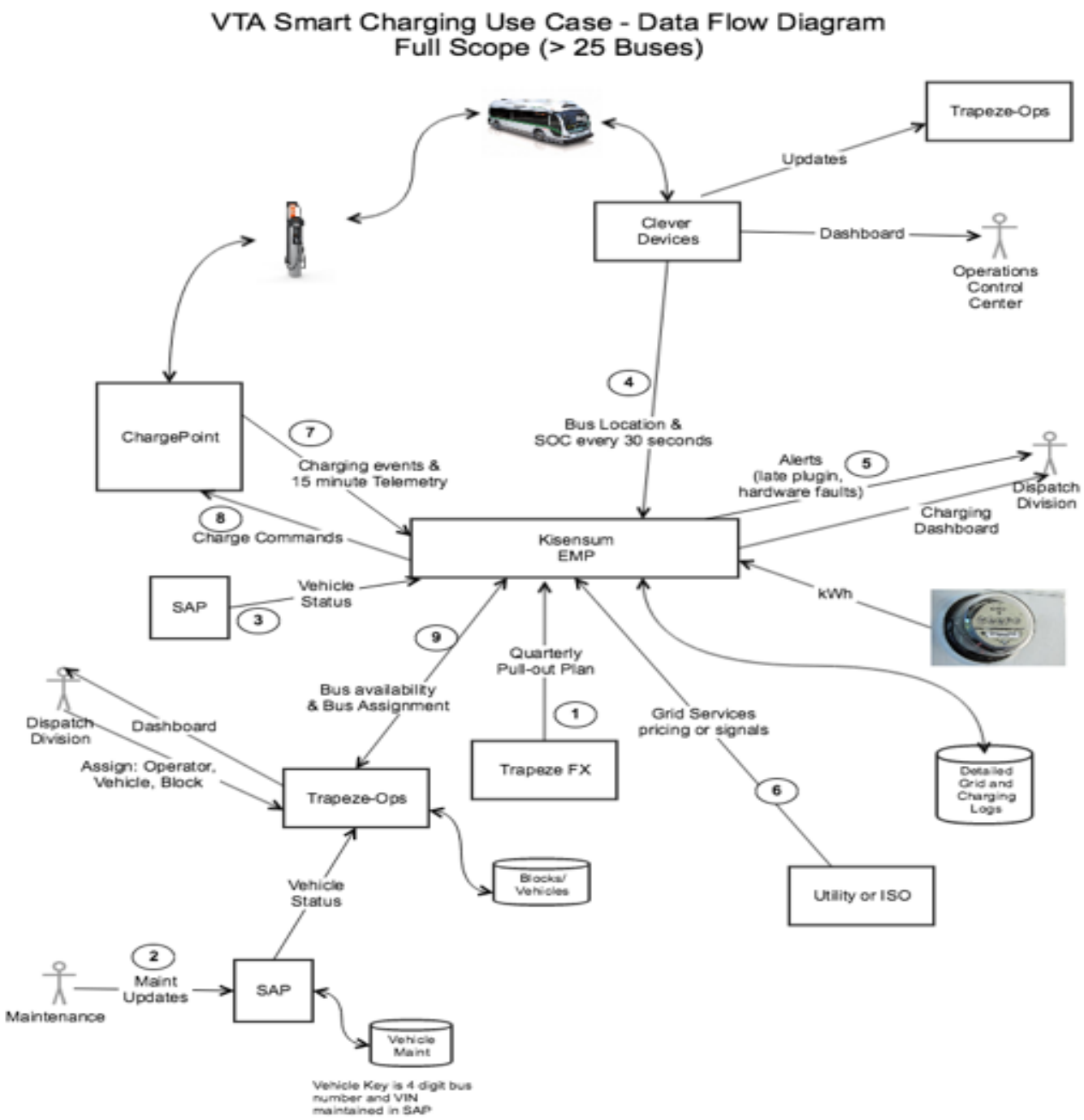
- Hybrid cloud Environment with collaborating applications
- Communication infrastructure reliant on standard protocols
- Up front review with key stake holders
- Key Considerations & Focus
  - High availability & Scale
  - Cyber Security
  - Interoperability & Standards
  - Service & Support
  - Reporting & Monitoring



Valley Transportation Authority

Data Flow Diagram

- **Inputs**
  - Trapeze-FX
  - Trapeze-Ops
  - SAP
  - ChargePoint Cloud
  - Clever Devices
  - Grid Signals
  - Electric Meter
- **Outputs**
  - Trapeze-Ops
  - ChargePoint Cloud
  - Clever Devices
  - Operators



PROSPECT Silicon Valley

Physical Infrastructure

Valley Transportation Authority

Major Technical Innovations

- Creating charge plans that support more buses than charge stations
- Energy Management Platform that interoperates with VTA and Grid systems
- Dashboard and alerting system supporting vehicle operations
- Realtime cost minimization process through demand leveling and Time of use aware charging
- Performing Grid Service simulations while not jeopardizing the bus charging operations

VTA Advanced VGI Project

Thank You!

Contact Information

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