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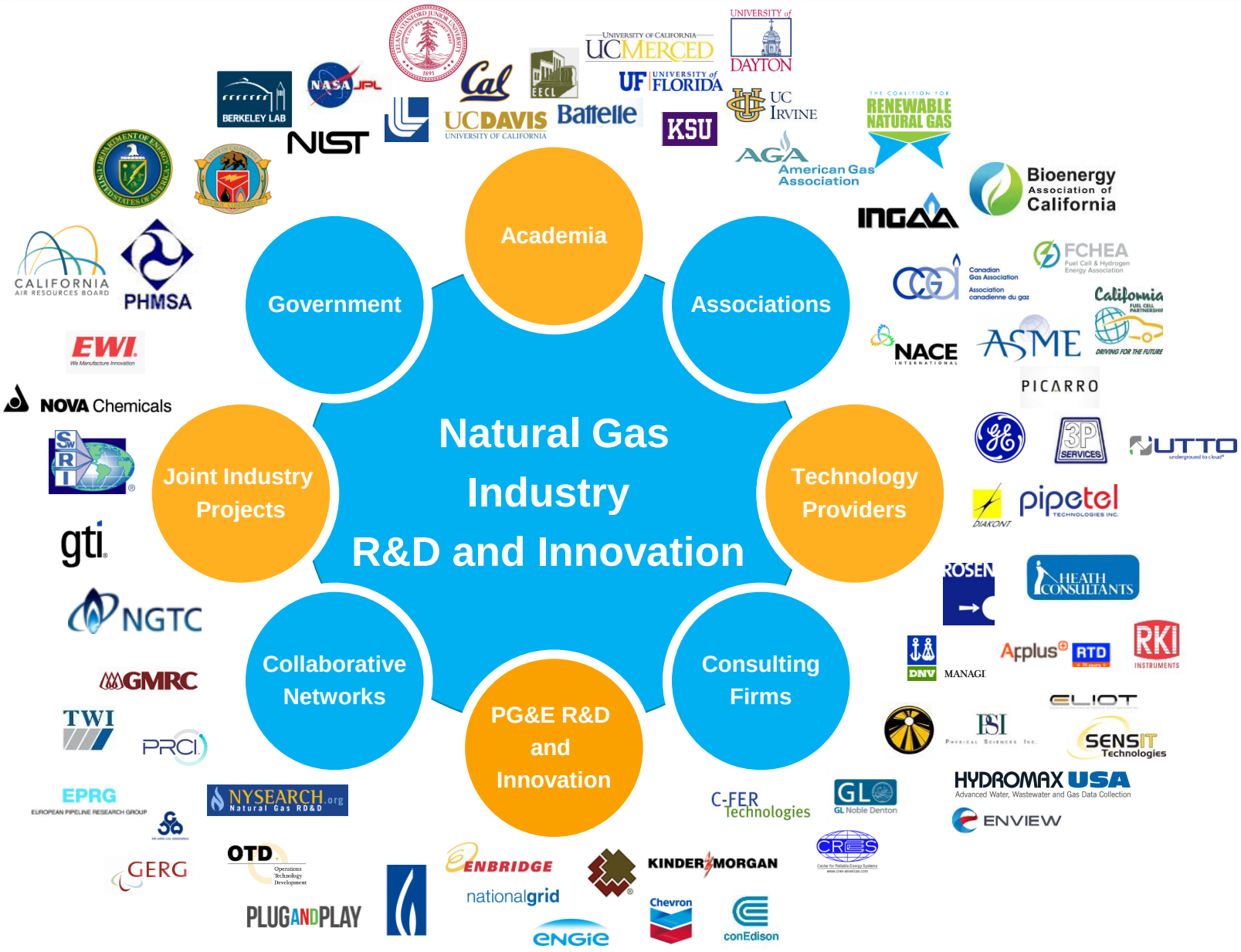
R&D and Innovation

François Rongere

May 2021

Together, Building
a Better California

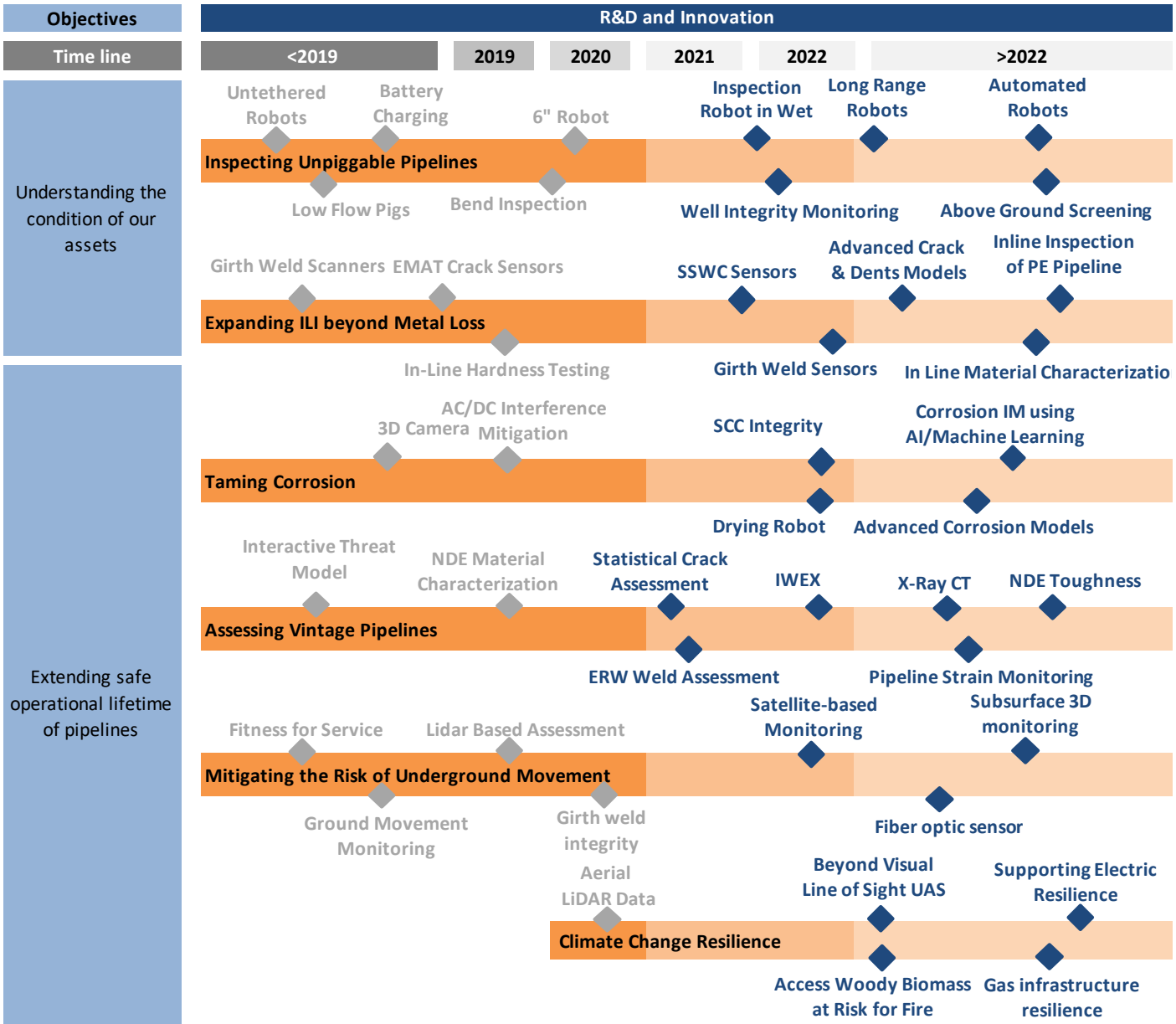
R&D and Innovation Network



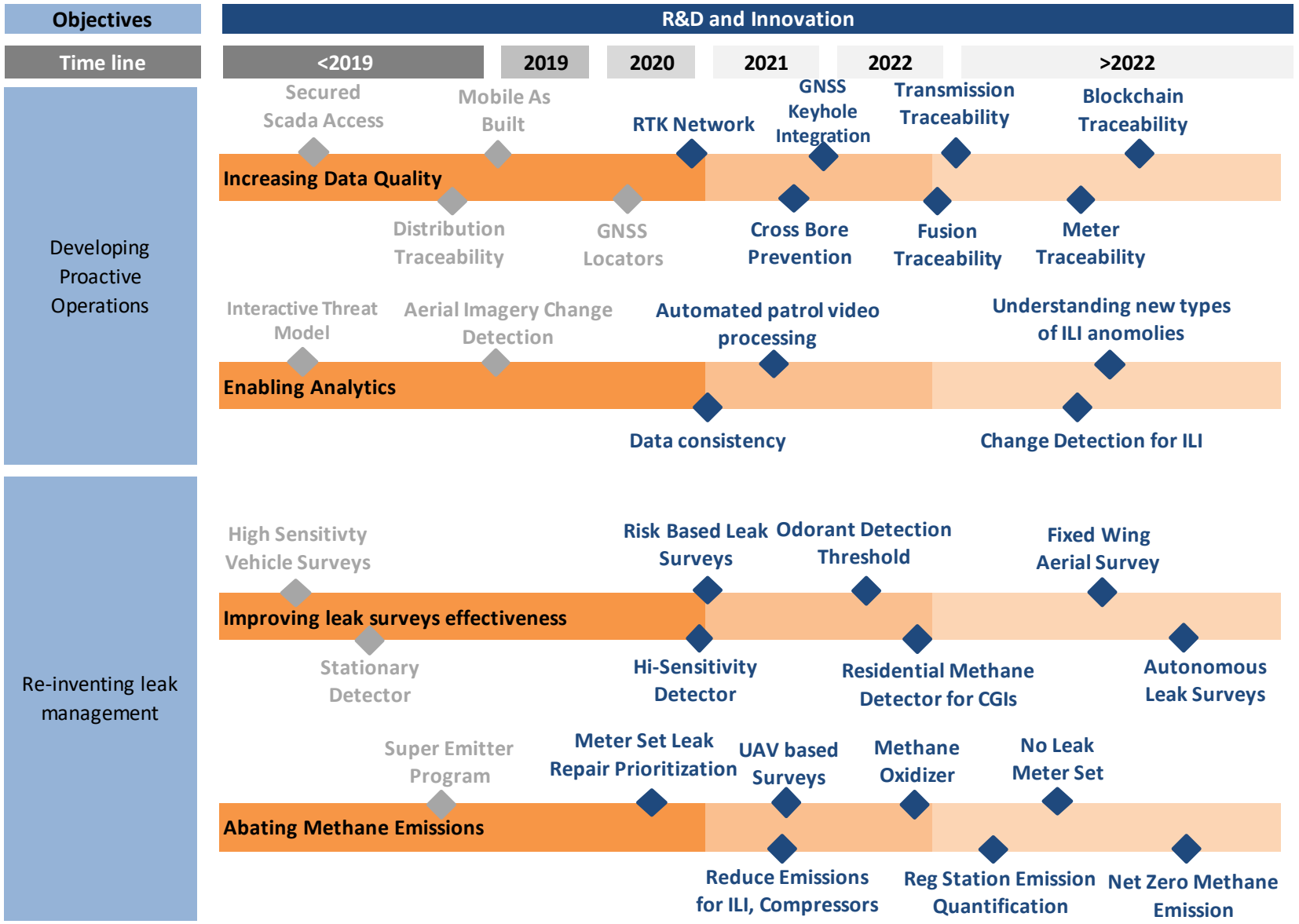
Seven Major Focus Areas

- Understanding the Condition of Our Assets
- Expanding Safe Operational Lifetime of Pipelines
- Developing Proactive Operations
- Reinventing Leak Management
- Eliminating Dig-ins
- Improving Construction Methods
- Decarbonizing the Gas System

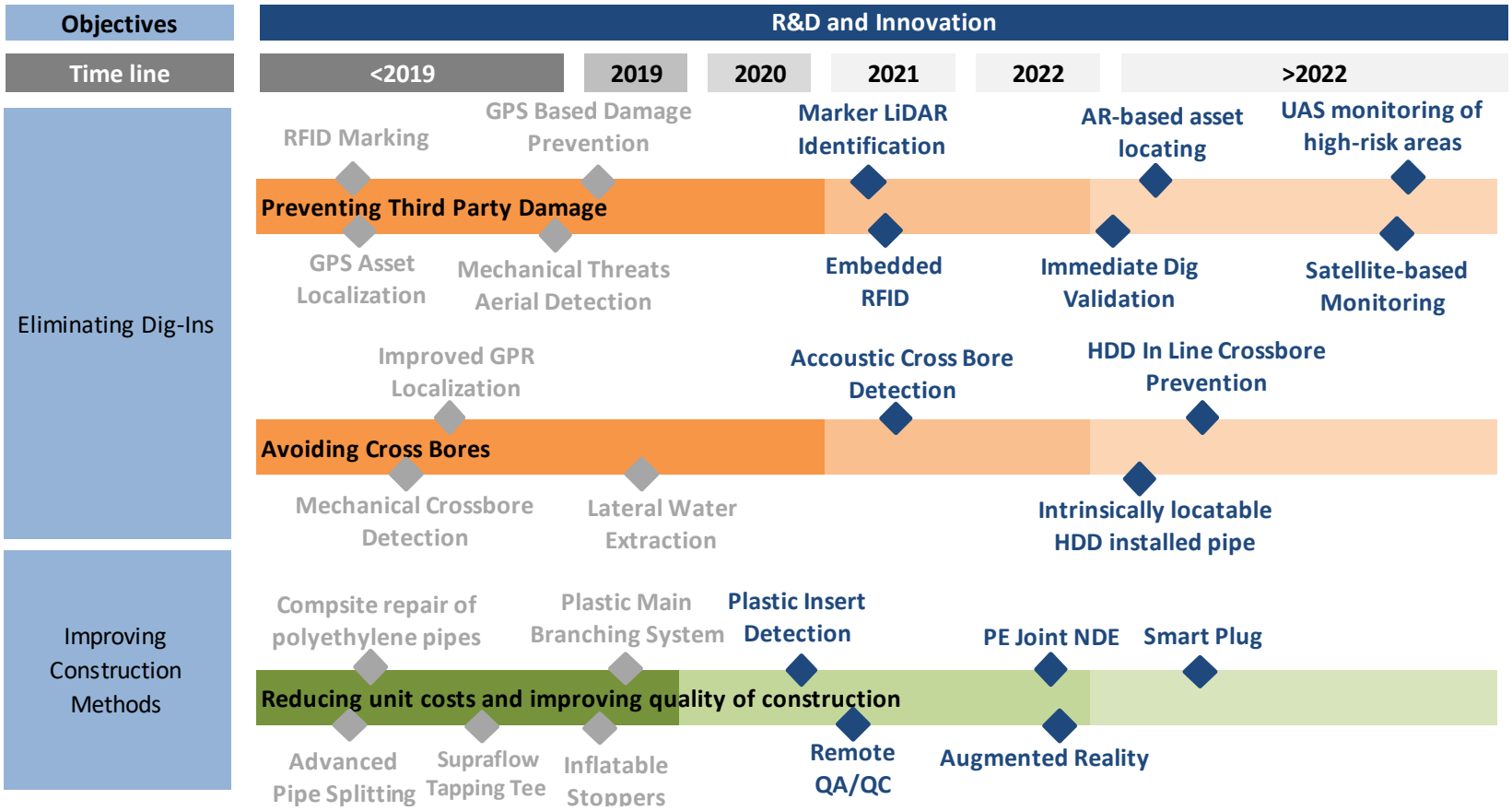
R&D and Innovation Road Map



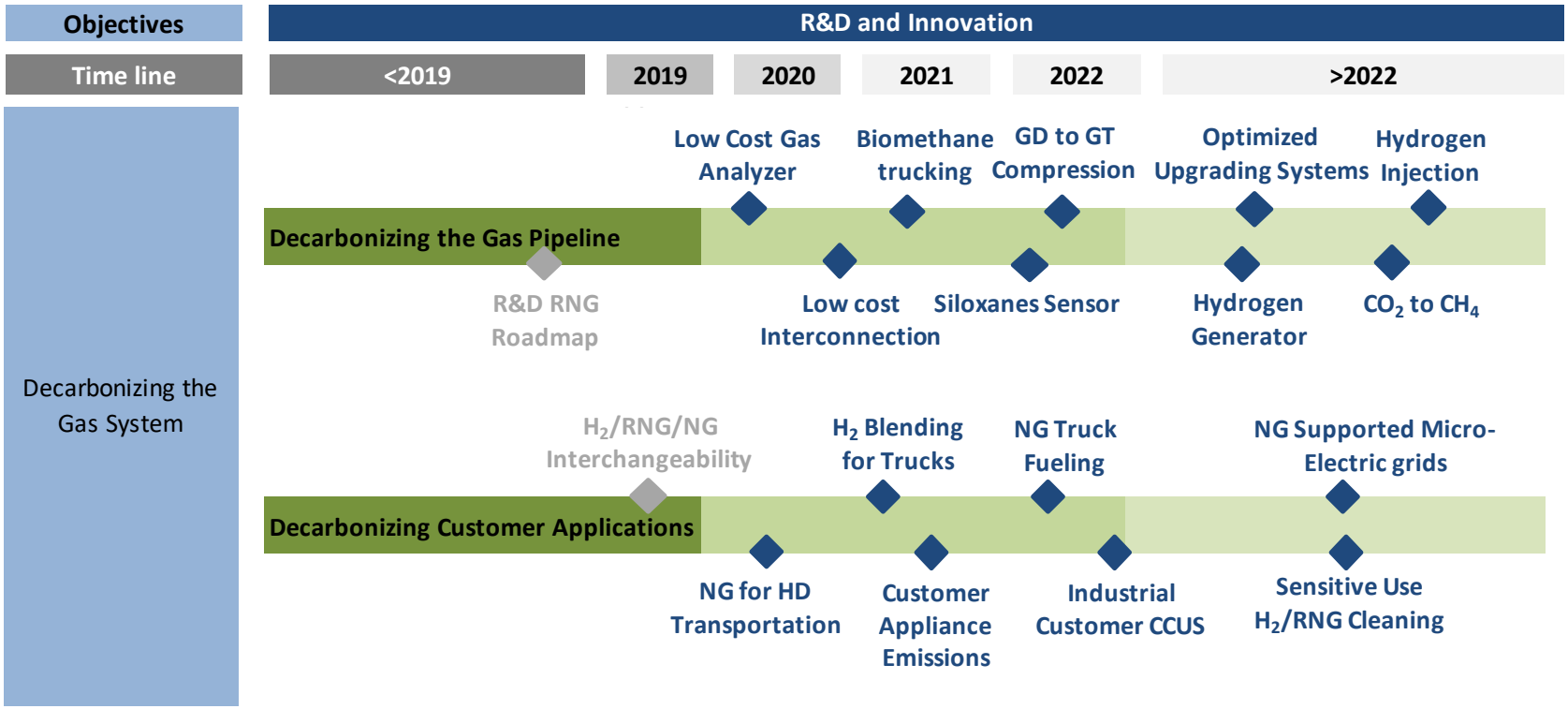
R&D and Innovation Road Map



R&D and Innovation Road Map



R&D and Innovation Road Map



Understanding the Condition of Our Assets

Robots to Inspect Un-Piggable Pipelines

Deployed since 2013:

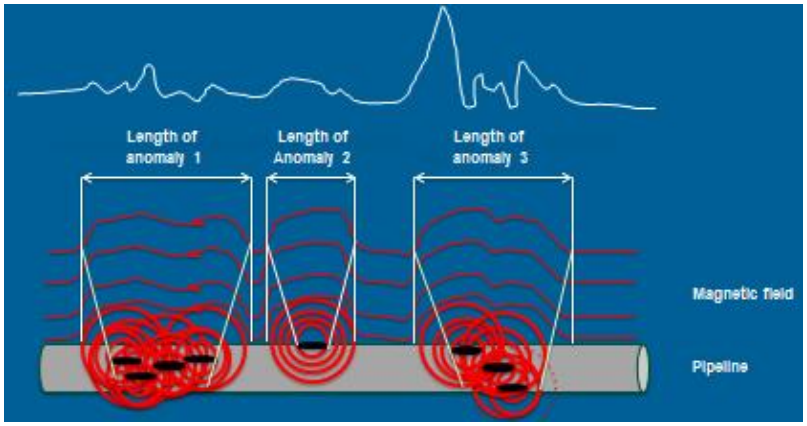
NYSEARCH.org Natural Gas RD&D

Diameter	# of inspections	Miles
8	5	2.9
10	5	0.95
12	14	5.65
16	7	2.58
20	11	4.02
22	1	0.19
24	18	9.54
26	1	0.36
30	2	0.85
36	1	1.06
Total	**65**	**28.10**

Recent new features:

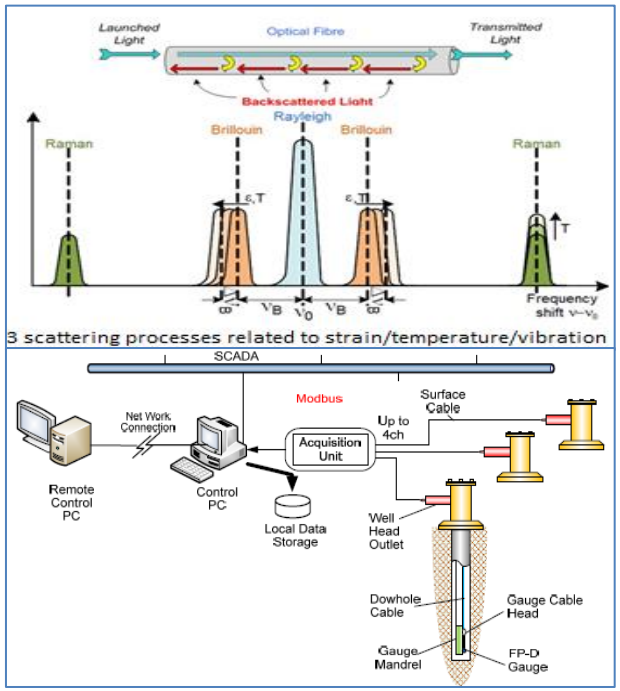
- TMFL module to detect crack-like features in seam welds
- In-Line Energy Harvesting to extend travel range
- Material characterization In-line hardness testing (completed in 2020)
- Automation – self driving with 3D cameras & IMU

Above-Ground Anomaly Screening & Monitoring



- Large Stand-off Magnetometry (LSM) detects passive geo-magnetization flux leakage at elevated stresses/strains in live pipeline
- Sensitive down to nano-tesla the sensor can be carried above ground by a technician or a drone
- Current projects
  - Modelling of the fundamental Physics
  - Field projects to support Geohazard Program with successful demonstration as a viable screening and complementary tool to the current practices

Fiber Optic Sensor



UGS Well monitoring overall system architecture

Pilot deployment and Strain Test Signal at a DIMP Fault Crossing Site

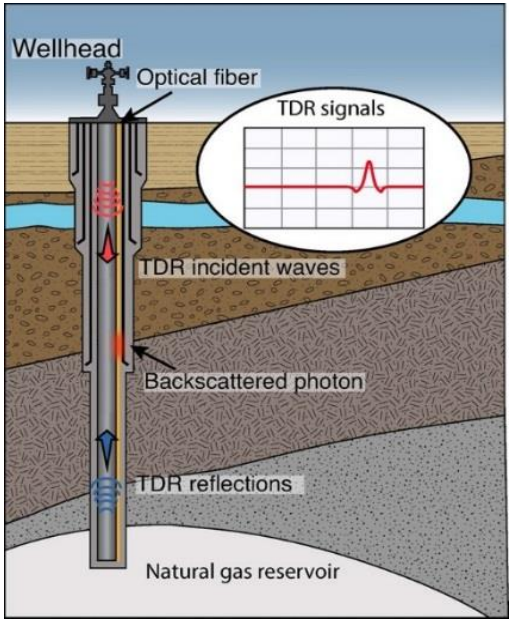
CALIFORNIA ENERGY COMMISSION

- UGS Well Integrity Monitoring
  - Distributed fiber optic sensor technologies for real-time temperature, acoustic/noise and strain monitoring
  - Field test at McDonald Island in collaboration CEC (#PIR-19-001 & 002)
  - Lab sensitivity test

PHMSA

- Pipeline Monitoring
  - Lab test funded by Paulsson in collaboration with PHMSA
  - Pilot Deployment at a DIMP Fault-Crossing site in Q4 2020 for monitoring from Q1 2021
  - Fault-Crossing Mitigation project in 2022 with UC Berkeley and Paulsson in collaboration with PHMSA

Electromagnetic Time Domain Reflectometry (EM-TDR)



Successful field operation test on an 800-ft deep oil well at Chevron's Cymric Oil field

- UGS Well Casing Monitoring/Screening
  - Electromagnetic guided-wave technology based on impedance change due to anomalies
  - Significant cost-saving potential of LBNL's non-intrusive EM-TDR for well casing application
  - Field test from Q2 2021 in collaboration with by CEC (#PIR-19-002)
- Pipeline Screening
  - High potential to complement UT guided-wave technology for screening or some difficult-to-inspect pipeline applications.
  - High interest from NYSEARCH members (proposal in development for March 2021 meeting)

Developing Proactive Operations

Distribution Mobile As-Built (MAB)

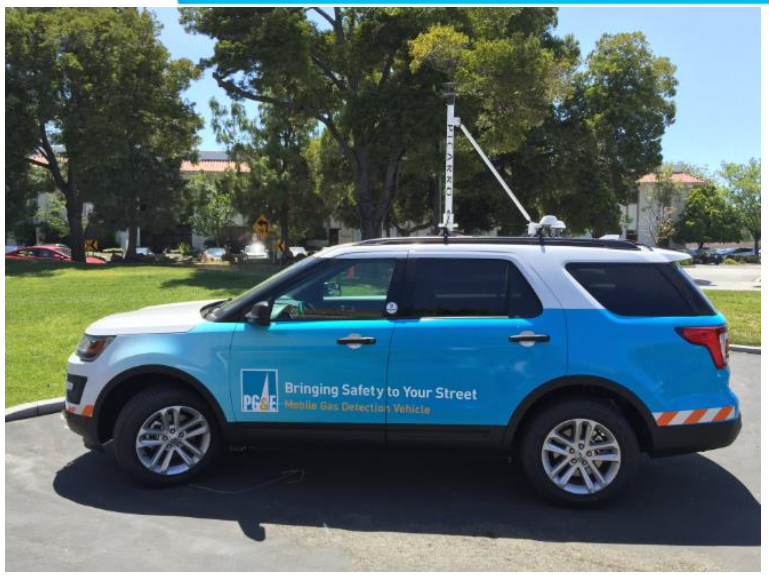
- First production roll-out to GC crews in Q3 2019
- All distribution mappers (~100) and GC field users (>100) trained with average GPS accuracy of 0.79 inches
- 705 total PM#s in-progress/completed with over 56 miles of gas mains and 34 miles of services recorded utilizing the MAB solution as of 2/28/21
- Paperless solution produces reliable, traceable, verifiable and complete as-built records
- Currently extended to transmission and contractors as well as integration with engineering

Re-Inventing Leak Management

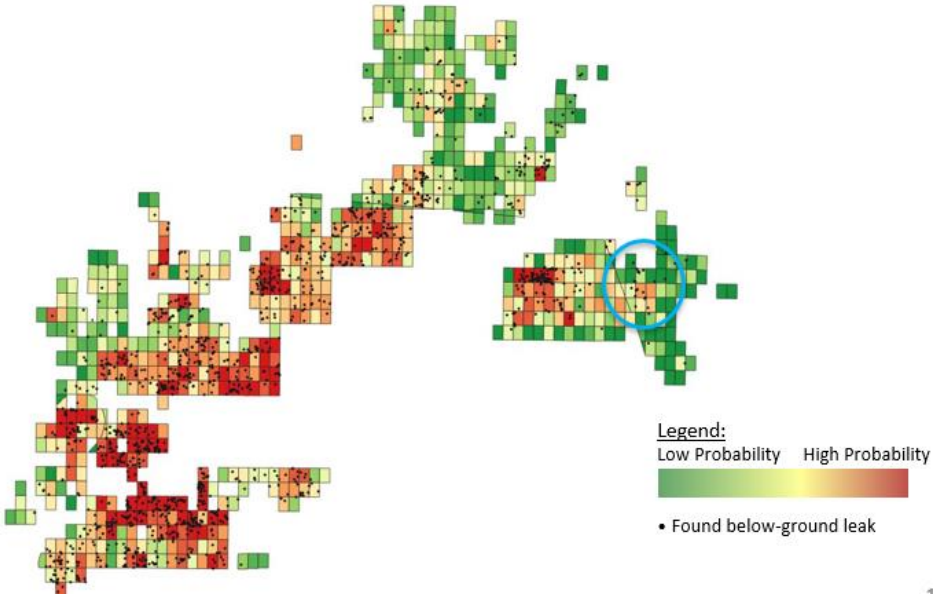
New Generation of Gas Survey Tools

- The Open Path Laser Spectrometer (OPLS) methane sensor is based on a prototype instrument design developed by NASA Jet Propulsion Laboratory (JPL) in 2014.
- Originally designed to hunt for traces of methane, which could be a sign of possible Mars life.
- This laser-based technology is lightweight and has superior sensitivity to methane.
- Unlike conventional technologies, designed with an open-path chamber which relies on passive migration of gas molecules into the sensor.
- Added features: cell-phone/tablet user interface, high accuracy GPS localization, ethane detection to confirm source, quantification algorithms, handheld and UAS mounted tool.

Risk Based Leak Surveys



Methane detection vehicle



Merging LoF and Leak Probability models

PICARRO

- Merges DIMP Likelihood of Failure (LoF) model and Mobile Monitoring model for leak probability
- Calculate the predicted numbers of found leaks for the existing list of plats to be surveyed.

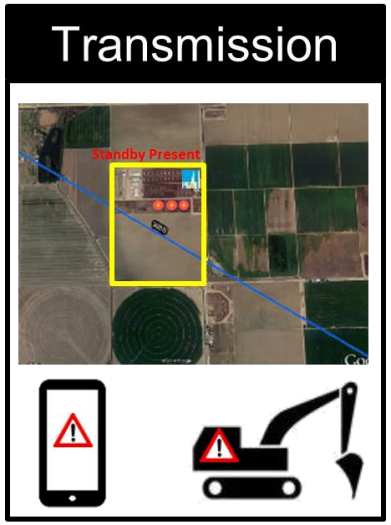
  Prioritize the plats to be surveyed to optimize number of leaks found, minimize the time leaks stay open

Eliminating Dig-Ins

GPS & Motion Sensor-Based Damage Prevention

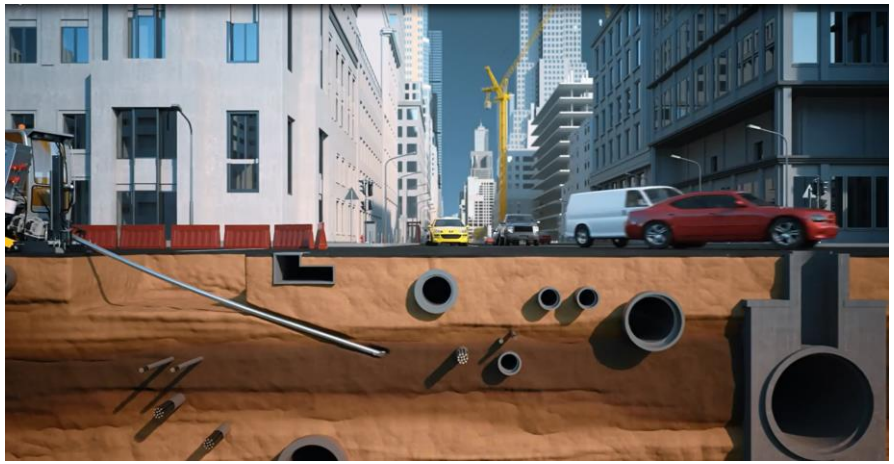
HYDROMAX USA
Advanced Water, Wastewater and Gas Data Collection

OTD Operations Technology Development

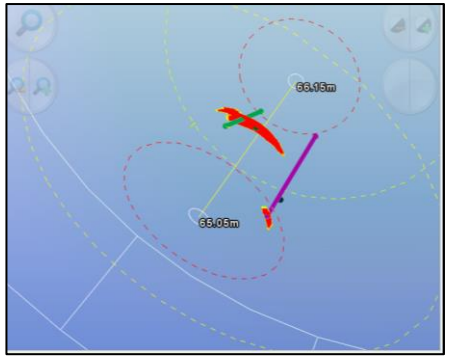


- Real-time activity monitoring of excavation equipment
- Alert Triggered when GPS indicates excavator within proximity to known pipeline location and/or AI detects when excavator is digging
- One Call Ticket incorporation allows for risk ranking and appropriate intervention when required

‘ORFEUS’ Borehead Radar



ORFEUS Demonstration full video (YouTube)



User interface showing detections

Installation of the Orfeus rod on a boring machine at PG&E in October 2017

- Ground Penetrating Radar embedded in drilling rods
- Real-time obstacle detection to increase the safety margins of HDD[1] utility installations
- Reduce likelihood of cross-bores
- Create agnostic retrofit compatible to any boring rig

[1]HDD: Horizontal Directional Drilling

Thank you!