HIGHLY DISPERSED ALLOY CATHODE CATALYST FOR DURABILITY

T. D. Jarvi
UTC Power Corporation
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Project ID # FCP 26

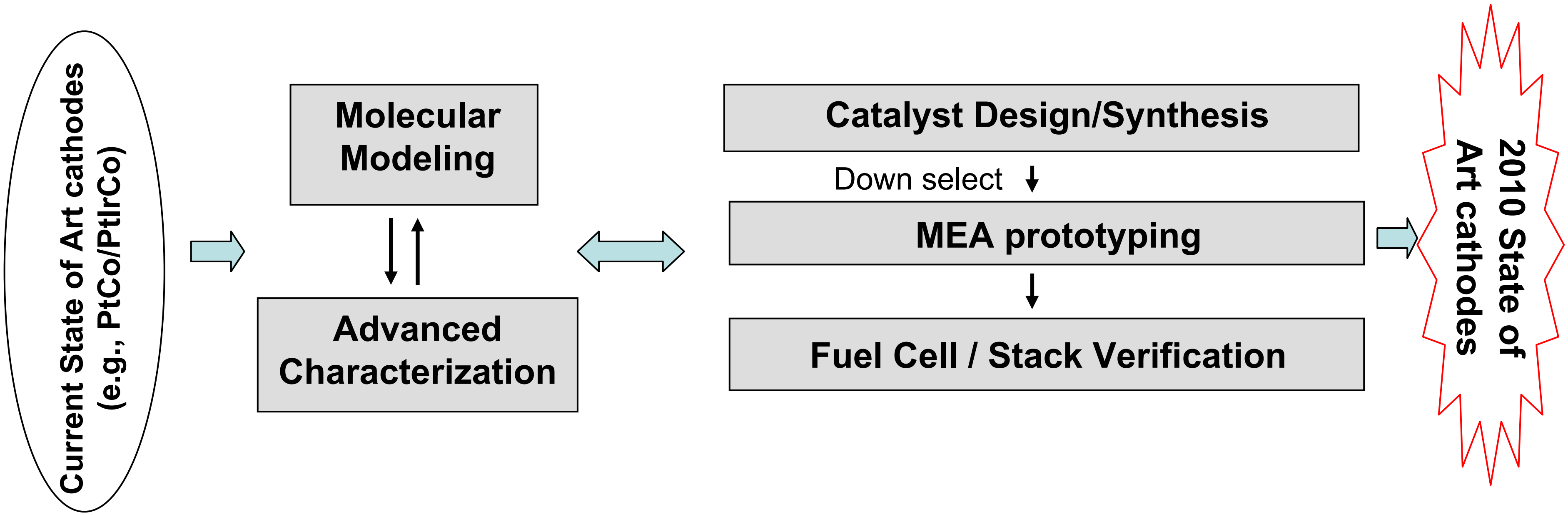
HIGHLY DISPERSED ALLOY CATALYST

Objectives of project

Characteristic	DOE 2010 Target
Pt group metal Total Content	0.50 g/kW rated
Pt group metal Total Loading	0.30 mg PGM/cm^2
Durability with cycling $\leq$80^{o}C; >80^{o}C	5000 h; 2000 h
Electrochemical Area Loss	< 40 %
Mass Activity at 900 mV$_{RHE\ (IR\text{-}Free)}$	0.44 A/mg Pt
Specific Activity at 900 mV$_{RHE\ (IR\text{-}Free)}$	720 µA/cm^2
Cost	$8/kW

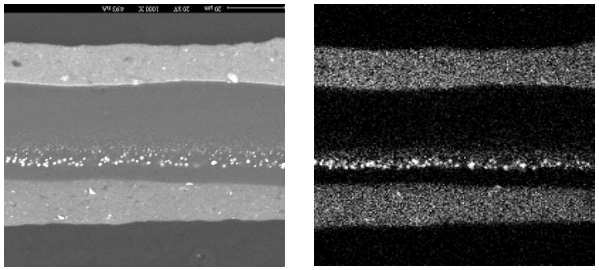
HIGHLY DISPERSED ALLOY CATALYST

Program approach



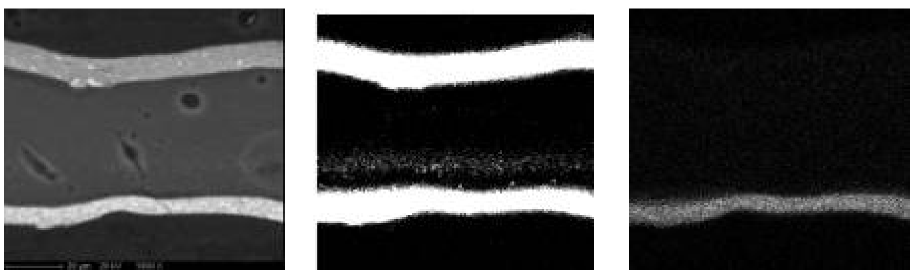
HIGHLY DISPERSED ALLOY CATALYST

Understanding high performance materials



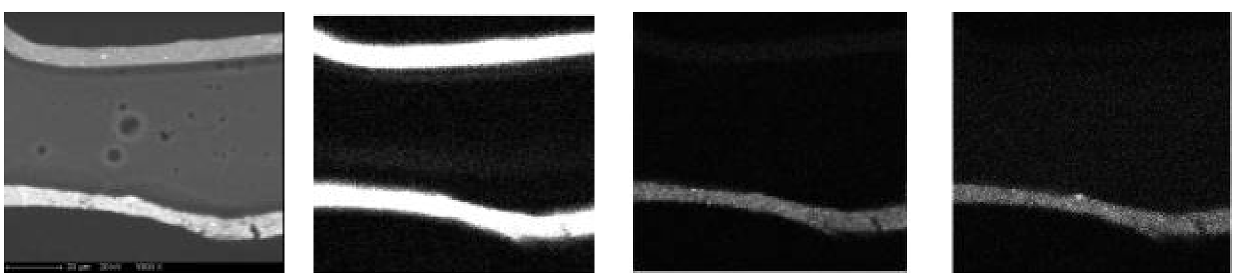
Pt/C cathode

B.S.E. Pt



PtCo/C cathode

B.S.E. Pt Co Ir



PtIrCo/C cathode

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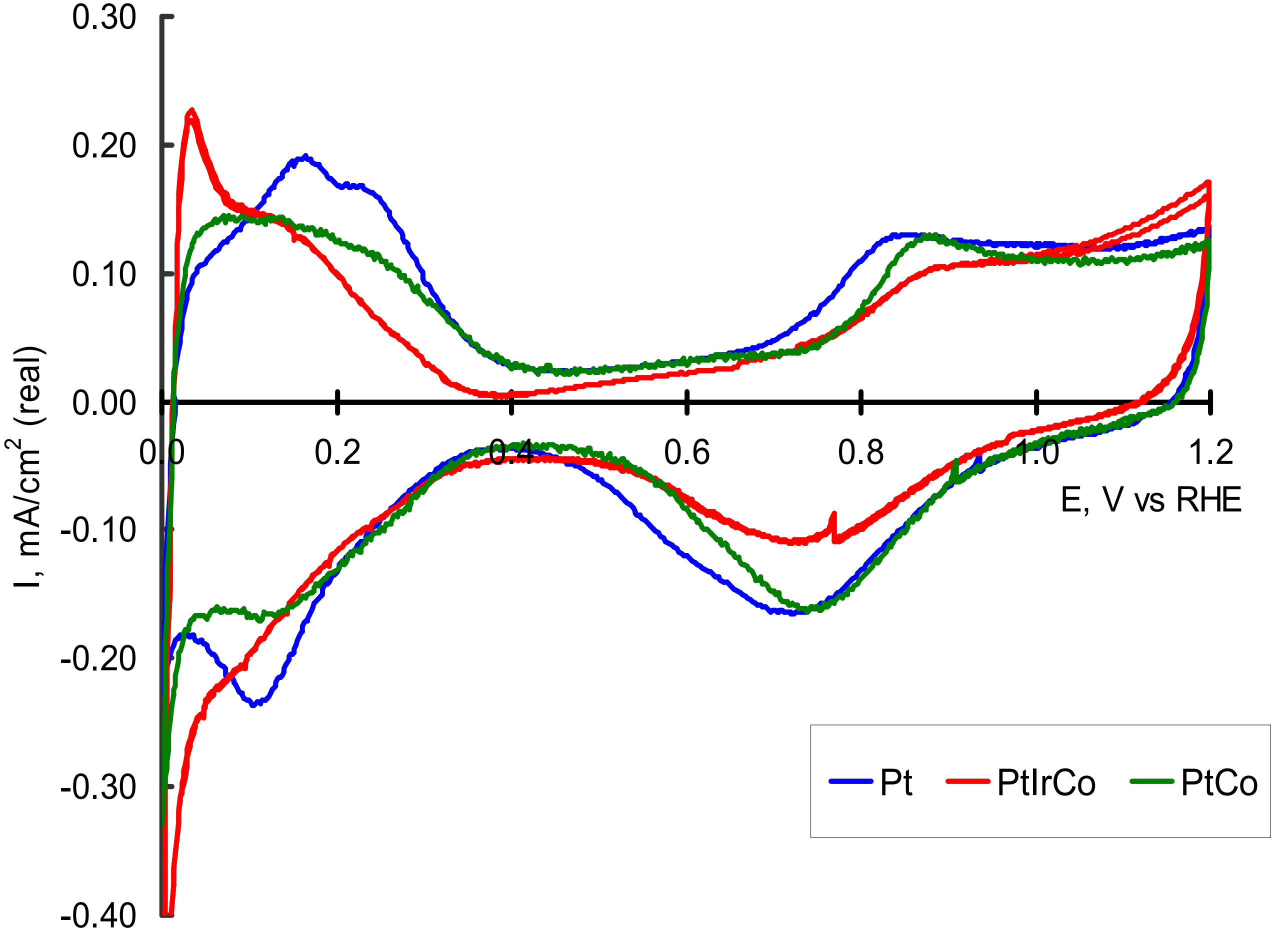
Understanding high performance materials



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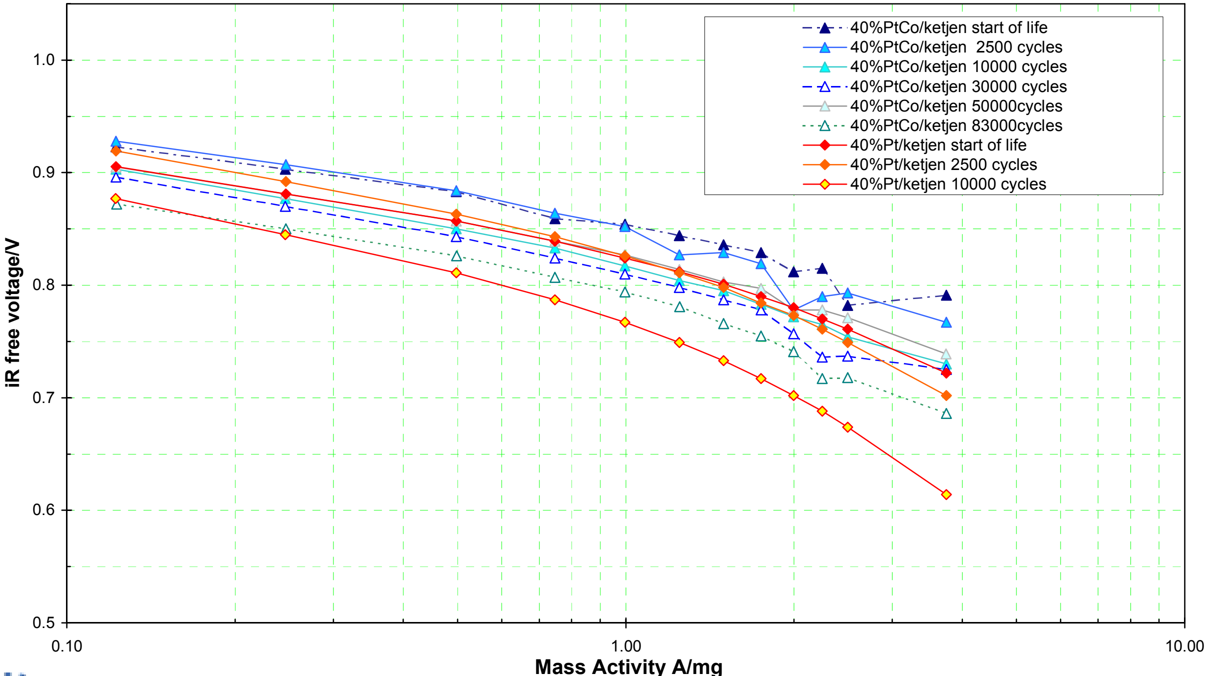
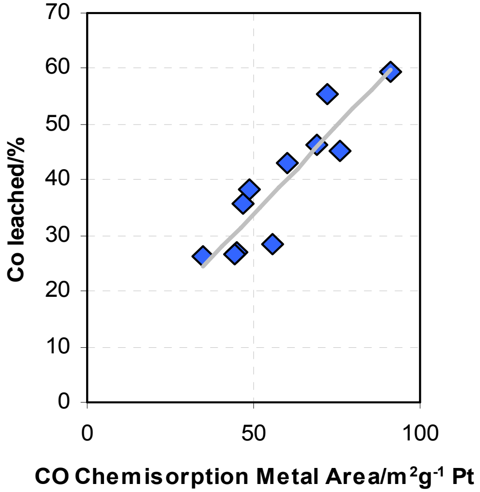
Understanding high performance materials

- Pt alloy catalysts show higher mass activity than Pt (0.25-0.3A/mgPt for Pt alloy)
- Pt alloy performance benefit retained after MEA voltage cycles 0.7-0.9V (iR-free)
- Co is leached from PtCo alloys – decreases activity
- Understanding these initial alloys drives future development

Cell at 80°C, Pressure 50/50 kPag, hydrogen/oxygen, 2/10 stoich, SH-30 membrane, Humidifier temperature 80/80°C



0.5M H_2SO_4, 363K, 24 hrs



Ex-situ acid leaching PtCo alloys shows Co removal strongly dependent on surface area/particle size

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Johnson Matthey Fuel Cells
the power within

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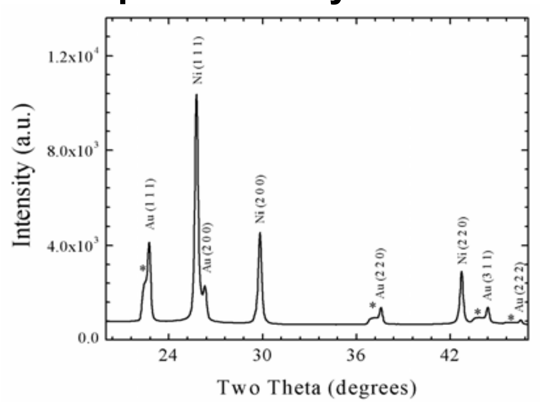
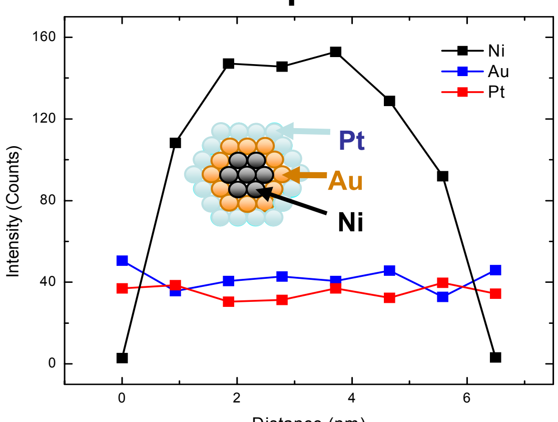
Model systems to develop understanding

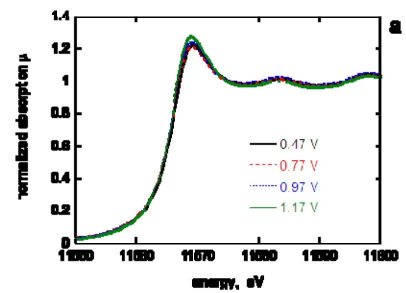
Segregation of Au in AuNi micro-powder x-ray diffraction

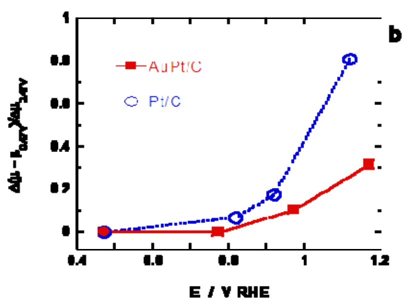


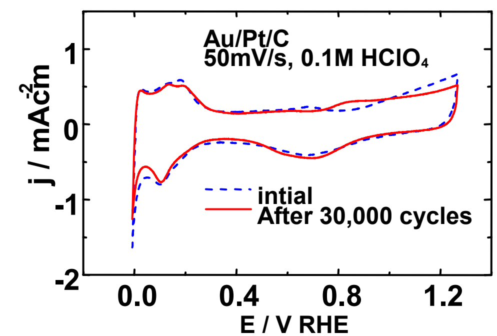
EDS of a Pt_{ML}/Au/Ni nanoparticle in nano-probe mode

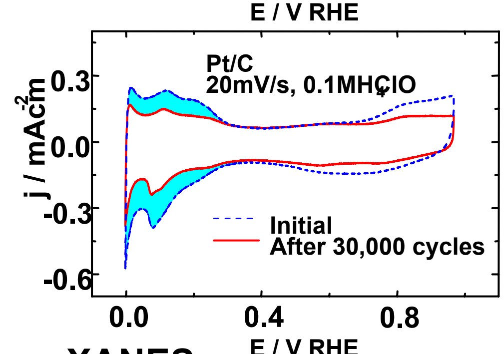


Learning from stabilization effects of Au clusters on Pt- no change in 30,000 cycles









Pt oxidation is decreased from XANES and Voltammetry

Au atoms may block the kink and step sites where PtO is formed first and Pt dissolution starts.

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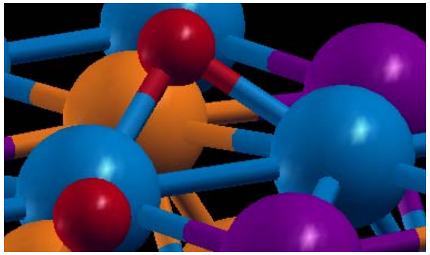
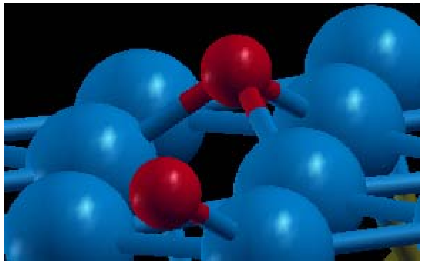
Modeling to understand materials

METHODS

Computational chemistry methods help to understand catalytic activity and metal dissolution

Thermodynamic analyses determine which alloys are more stable than Pt against dissolution





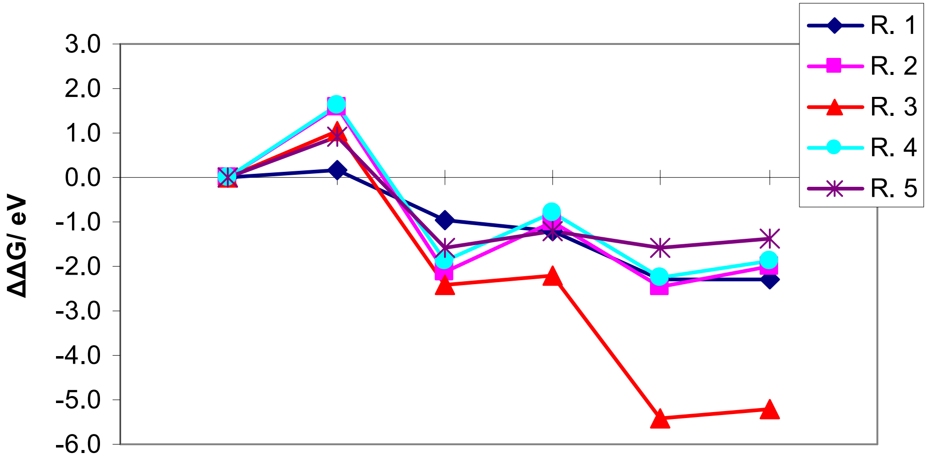
Oxygen attachment to atoms on the metal surface is the first step in the dissolution process

We calculate:

$\Delta\Delta G_{rxn\,i} = \Delta G_{rxn\,i}|_{Alloy} - \Delta G_{rxn\,i}|_{Pt}$

If $\Delta\Delta G < 0$ alloy atom easier to dissolve than Pt

If $\Delta\Delta G > 0$ alloy atom more stable than Pt



Gu and Balbuena, JPCB 2006

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TEXAS A&M UNIVERSITY
DEPARTMENT OF CHEMICAL ENGINEERING

Perla B Balbuena
balbuena@tamu.edu

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Program team

UTC Power A United Technologies Company	Catalyst fundamentals Catalyst development Verification
JM Johnson Matthey Fuel Cells the power within	Catalyst development : alloys, supports, MEA Prototyping
Columbian	Catalyst development : supports
Brookhaven National Laboratory Office of Science / U.S. Dept. of Energy	Catalyst fundamentals: experimental
ATM	Catalyst fundamentals: modeling

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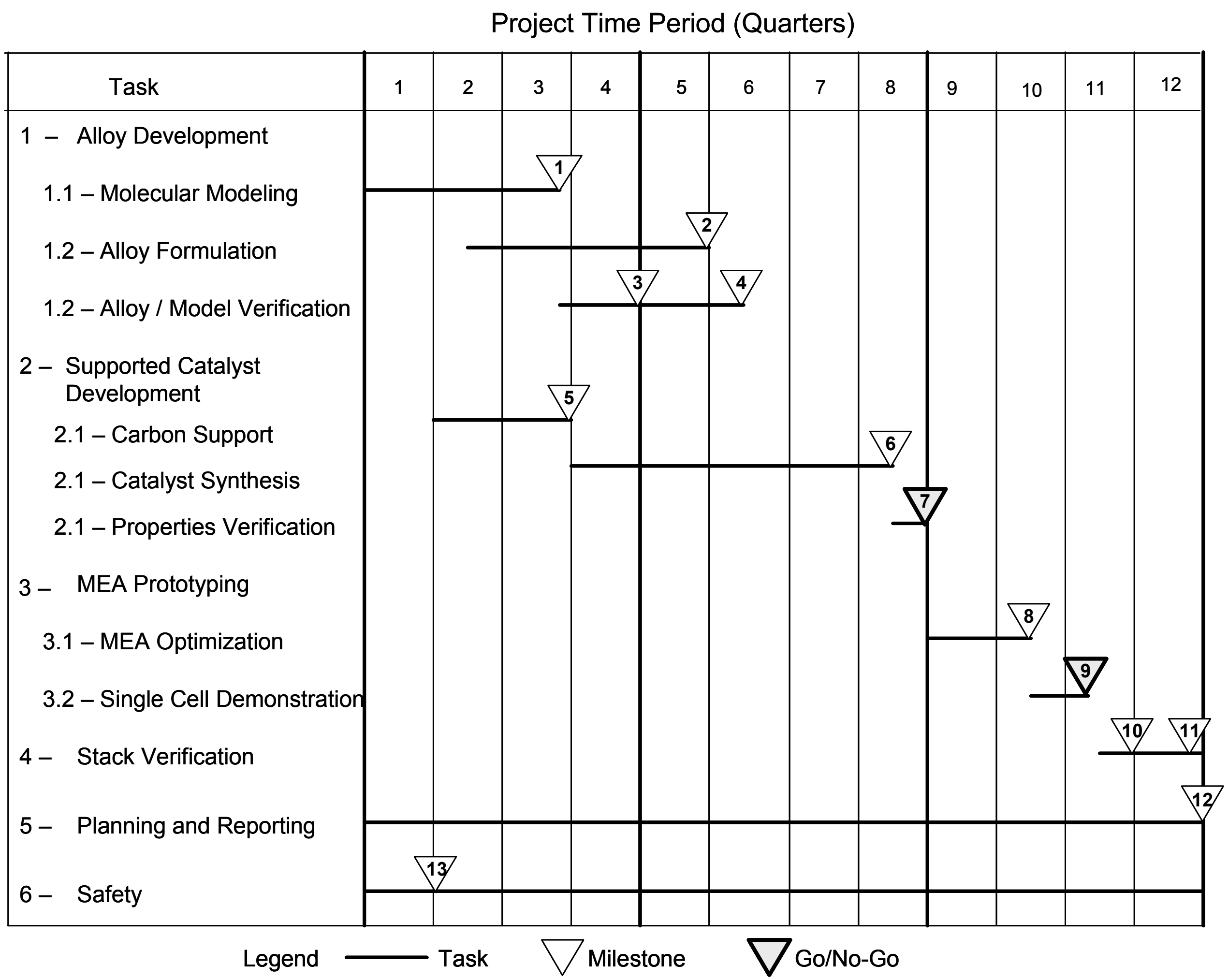
Project timeline



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Program budget (total program)

Government Fiscal Year ’07	$2,214,267
Government Fiscal Year ’08	$2,868,363
Government Fiscal Year ’09	$2,736,472
Government Fiscal Year ’10	$669,319

Cost share – 25%