HIGHLY DISPERSED ALLOY CATHODE CATALYST FOR DURABILITY

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UTC Power Corporation

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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 $\leq 80^oC$; $>80^oC$	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 $\mu A/cm^2$
Cost	$8/kW

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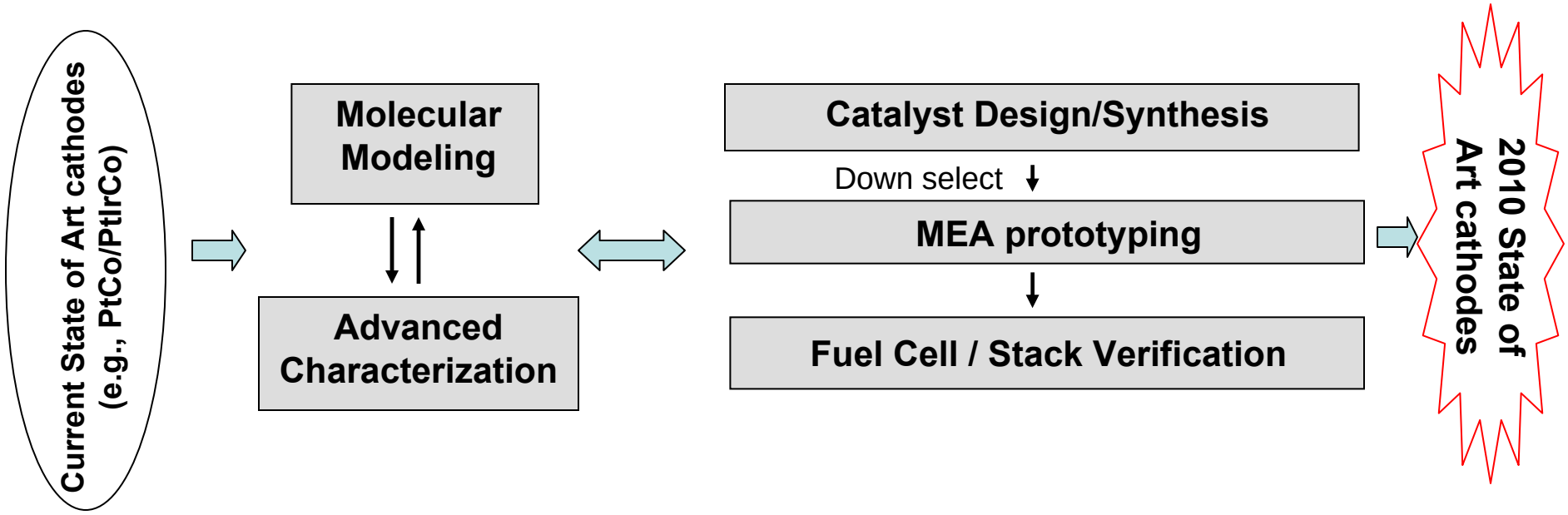
Program approach



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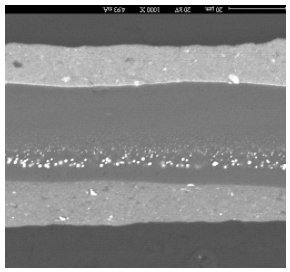
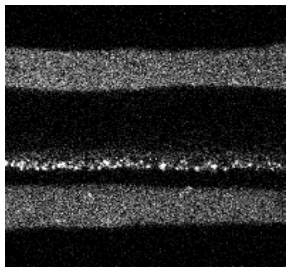
Understanding high performance materials

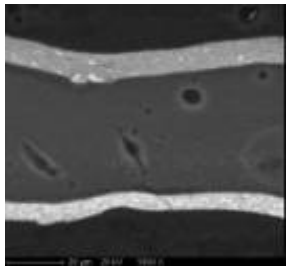


B.S.E.



Pt

Pt/C cathode



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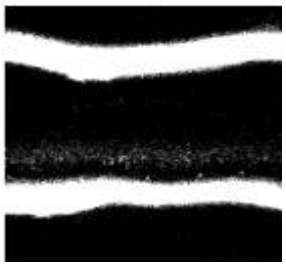
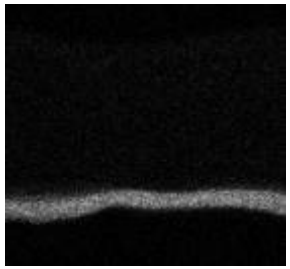
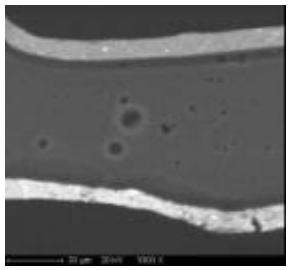


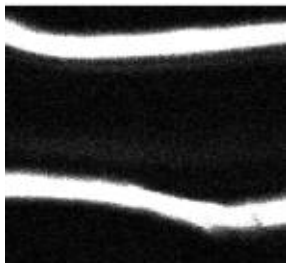
Pt

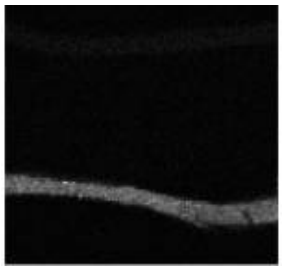


Co

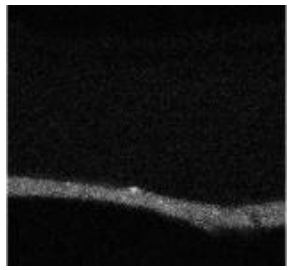
PtCo/C cathode







Ir



PtIrCo/C cathode

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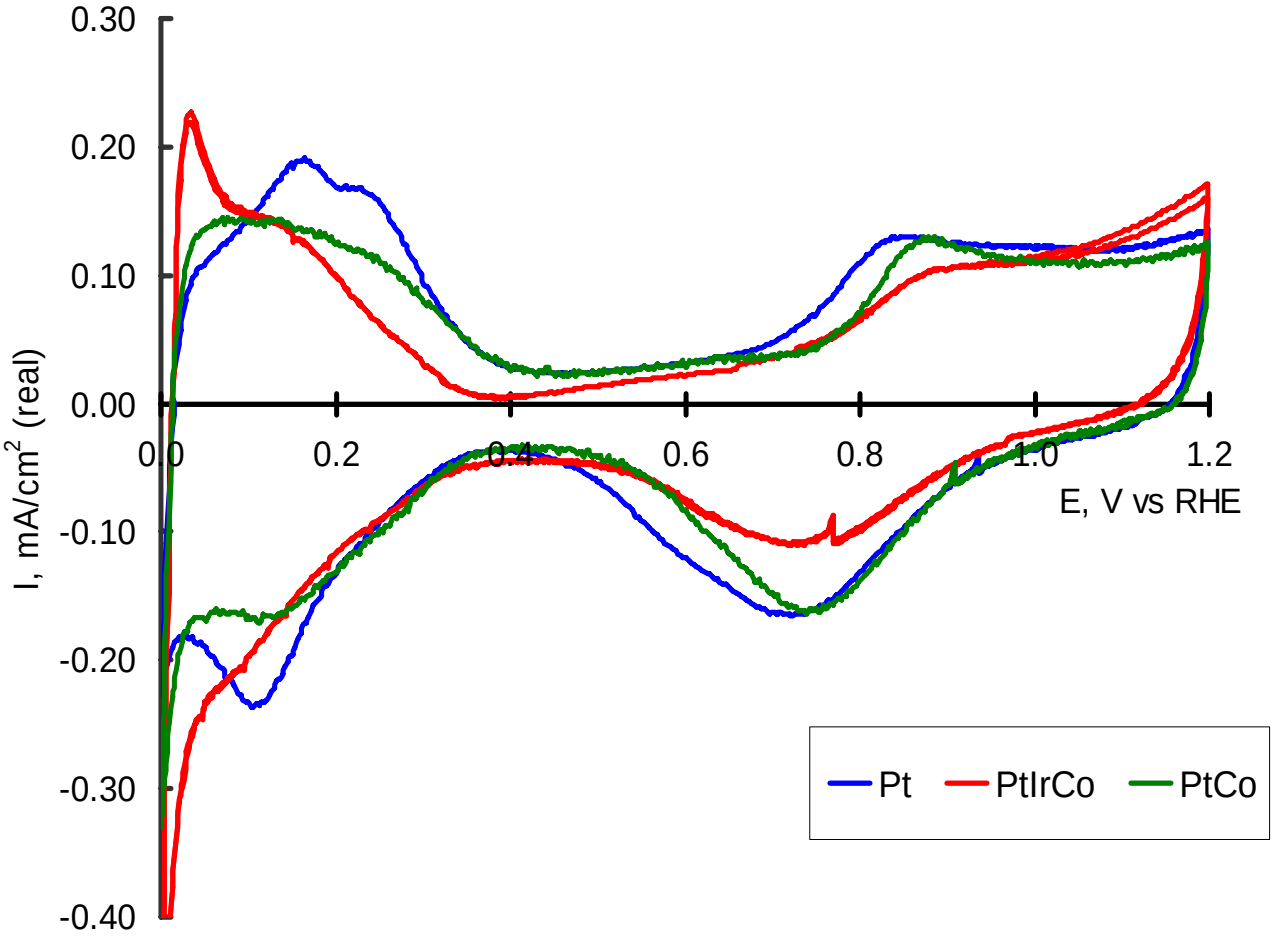
Understanding high performance materials



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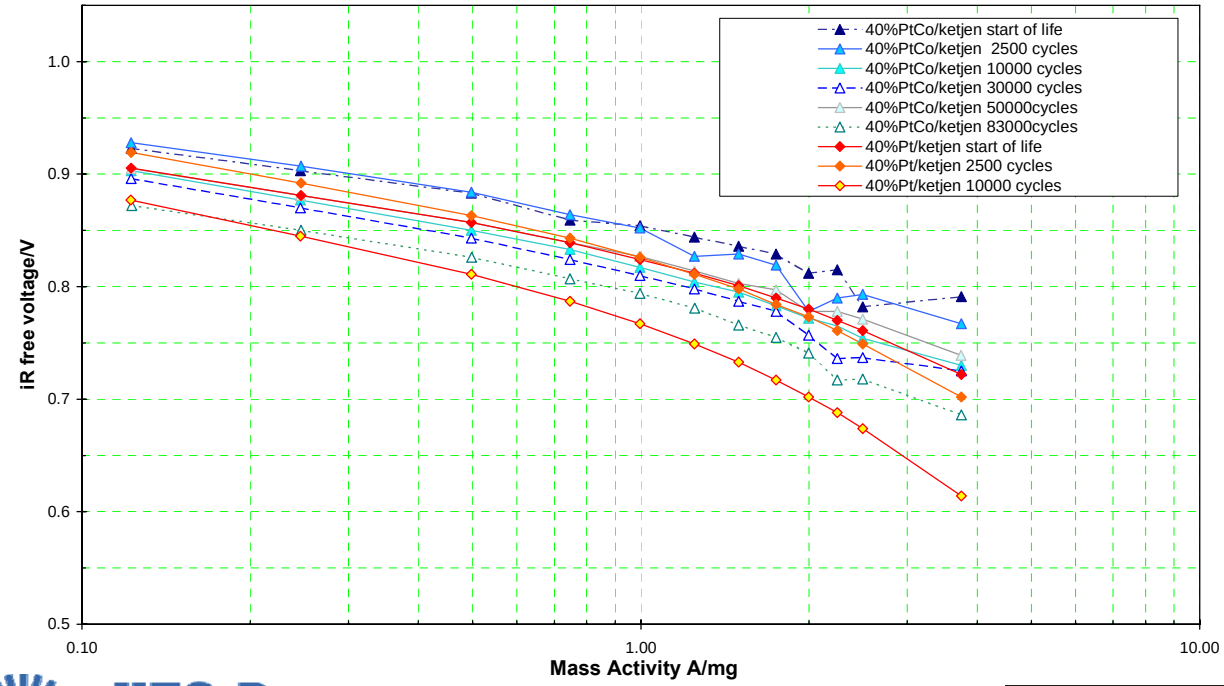
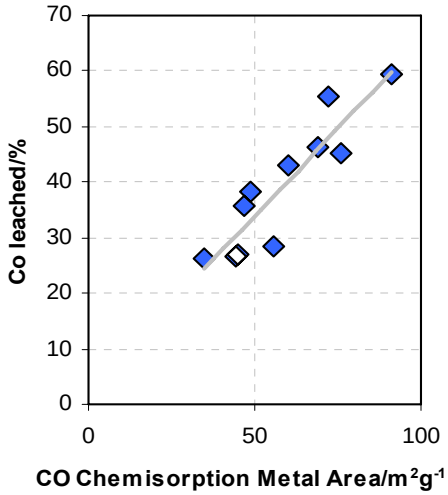
Understanding high performance materials

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 0.7-0.9ViR 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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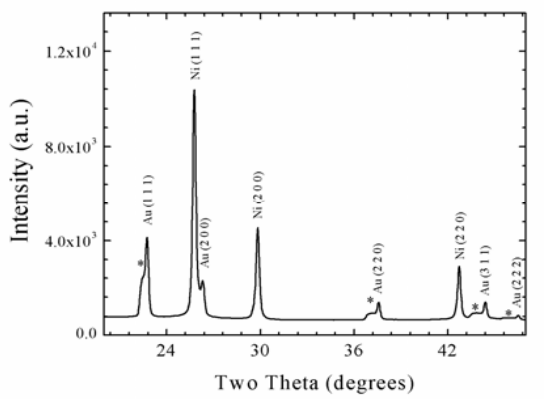
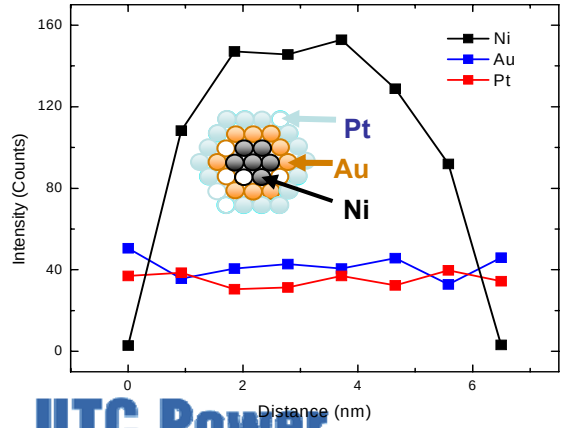
Model systems to develop understanding

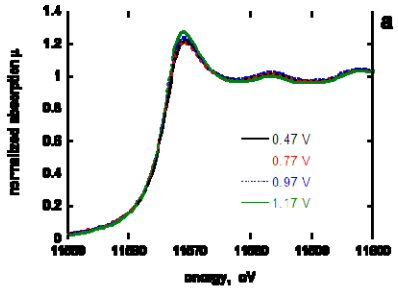
Segregation of Au in AuNi micro-powder x-ray diffraction

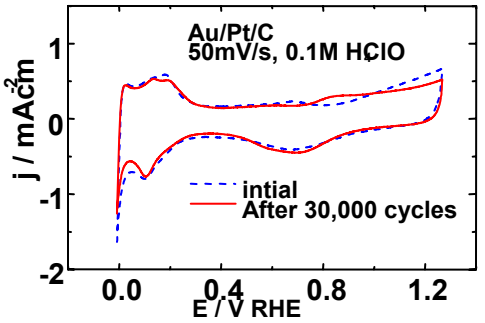


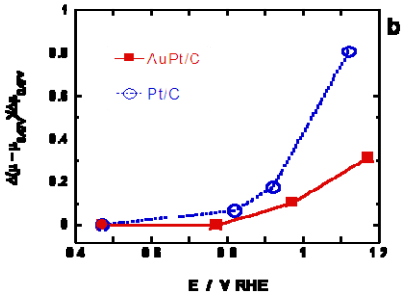
EDS of a Pt_{ML}/Au/Ni nanoparticle in nano-probe mode

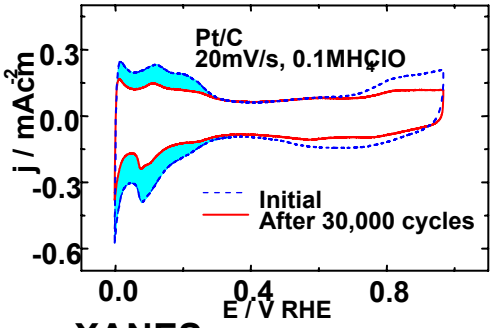


Learning from stabilization effects of Au clusters on Pt- no change in 30,000 cycles









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

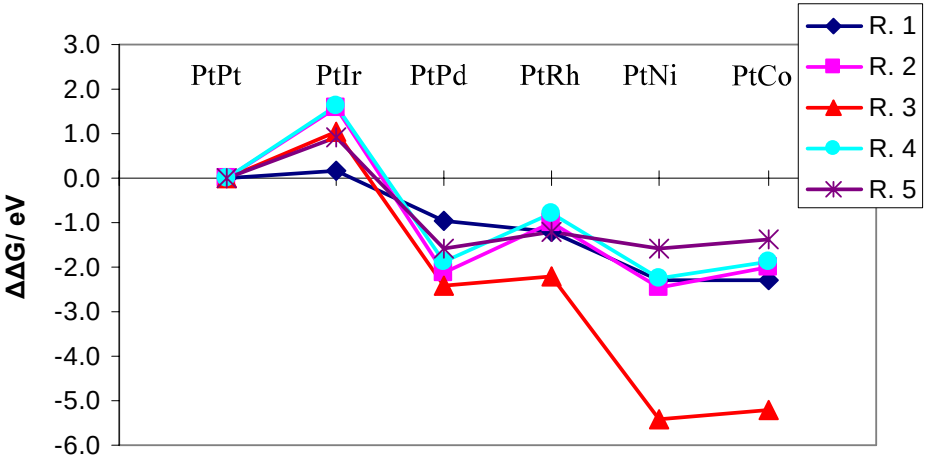
Thermodynamic analyses determine which alloys are more stable than Pt against dissolution

We calculate:

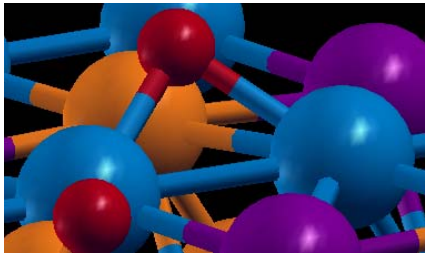
$\Delta\Delta G_{rxni} = \Delta G_{rxni}\,|_{Alloy} - \Delta G_{rxni}\,|_{Pt}$

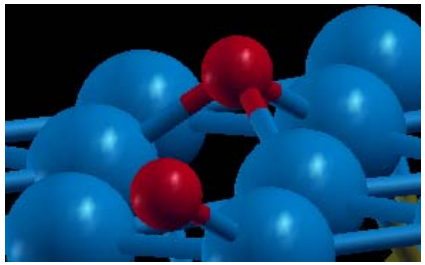
If $\Delta\Delta G < 0$ alloy atom easier to dissolve than Pt

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



Gu and Balbuena, JPCB 2006





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

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Program team

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

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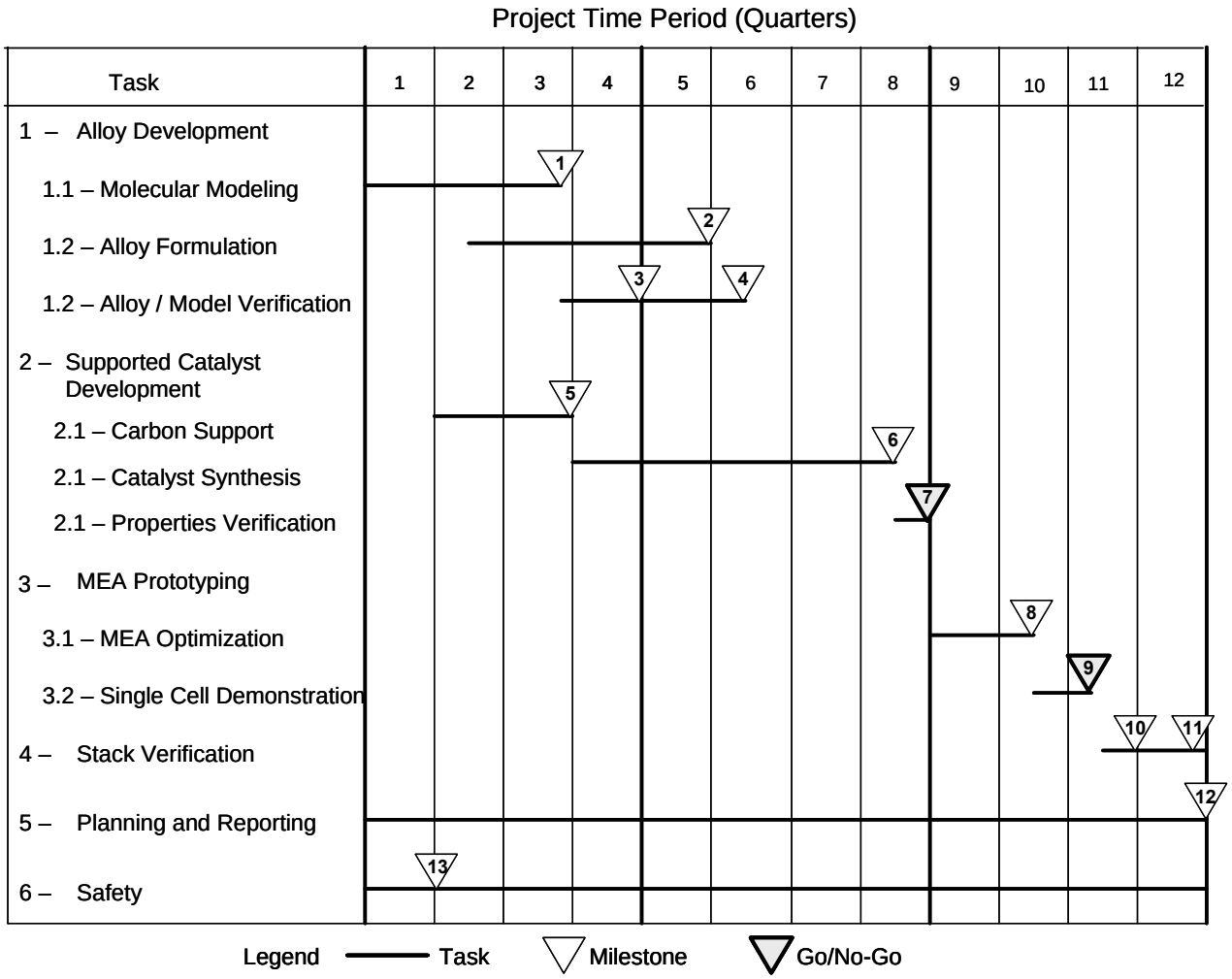
Project timeline



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Program budget (total program)

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

Cost share – 25%

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