

Concurrent Engineering at the JPL Innovation Foundry



JPL Innovation Foundry

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Concurrent Engineering evolves to meet evolving needs

- JPL is a primary NASA resource for helping the science community ideate, mature, and propose concepts for new missions
- Environmental context for the formulation lifecycle evolves continuously
- JPL continuously “system engineers” requirements and solutions for providing formulation support and winning new missions
- The **JPL Innovation Foundry** is an integrated formulation lifecycle enterprise



JPL Innovation Foundry

NASA science mission community faces a ratcheting challenge

Simultaneous, competitive formulation...

...of a large number

...of deeply engineered concepts

...for ambitious science objectives

...achieved using well-understood subsystems

...formulated on a strict diet

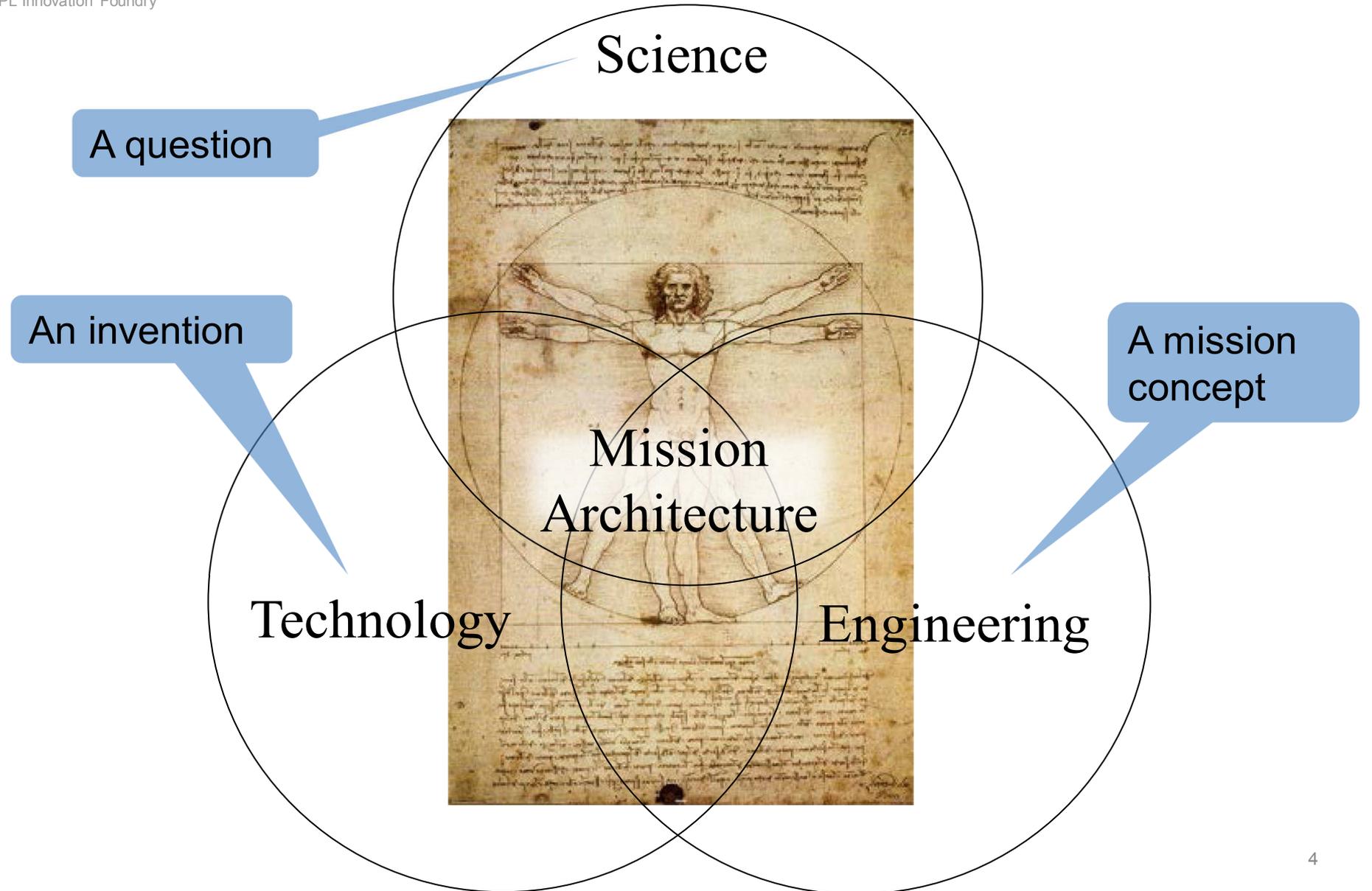


What All PIs and SDTs Need

- Darwinian evolution of a seed idea
 - Maturation into a toughened concept baseline
 - That can win, fly, and deliver
- Accurate forecasting despite incomplete data
 - Of the eventual state of truth regarding cost and risk
 - Of how others will model that state of truth when evaluating the concept

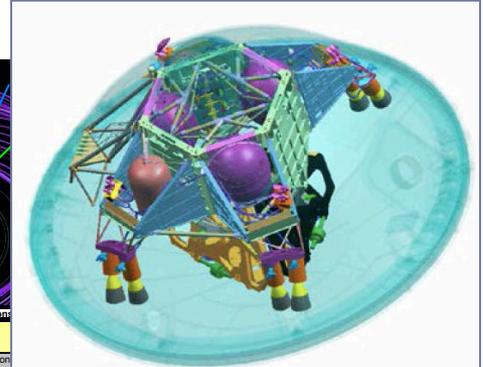
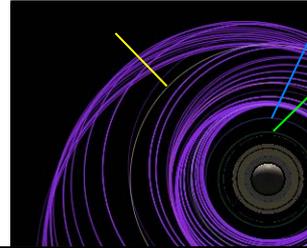


Every mission starts with a spark



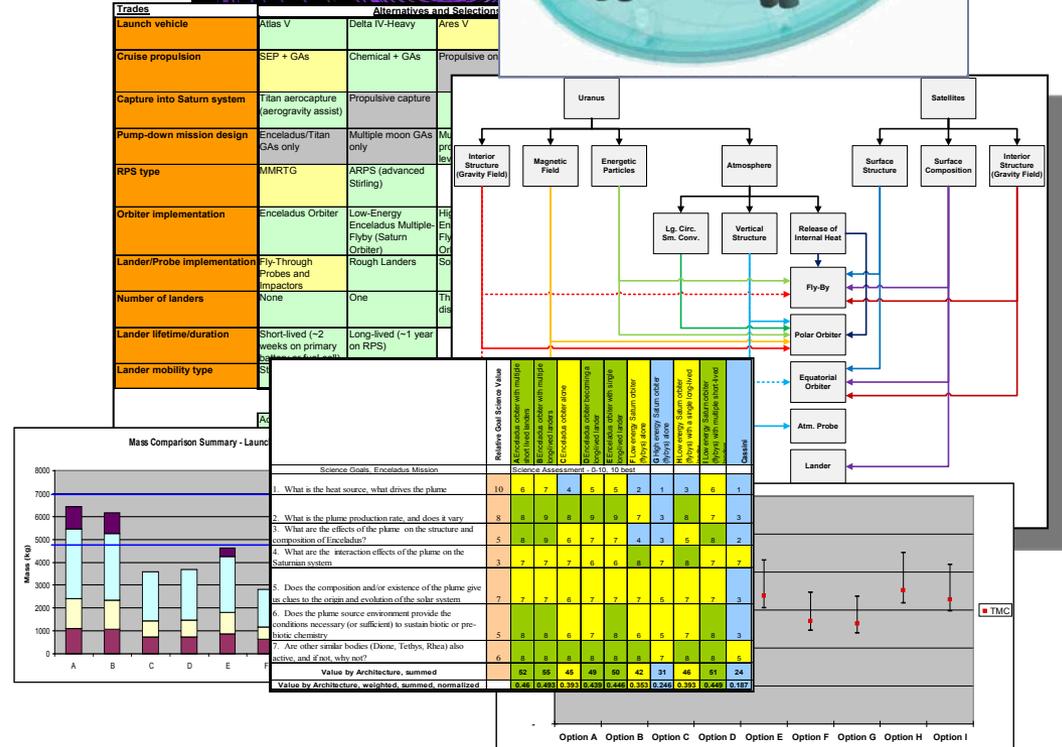


...then the concept is developed



or

One man's concept is another's doodle...





26 Elements of a Mission Concept

Technical

- Science Objectives & Requirements
- Mission Development
- Spacecraft/Instrument System Design
- Ground System Design
- Technical Risk
- Technology
- Inheritance
- Master Equipment Lists
- Technical Margins
- Trade Studies
- Modeling & Simulation
- Launch Services
- Planetary Protection
- Verification & Validation

Programmatic

- Acquisition and Surveillance
- Project Organization
- Schedules & Margins
- Cost Estimation & Risks
- Project Scope
- Documentation
- NEPA Compliance
- Subsystem Make-Buy
- Work Breakdown Structure
- Testbeds, Models & Spares
- Export Compliance
- Mission Assurance Management



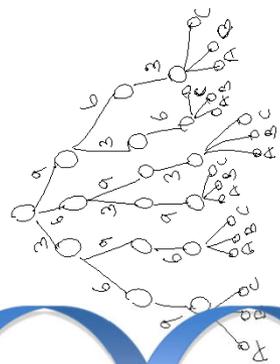
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Concept Maturity Level (CML) Benchmarks *Before* NASA Gates

Cocktail Napkin



Trade Space



Baseline Concept



Preliminary Implementation Baseline



CML 1

CML 2

CML 3

CML 4

CML 5

CML 6

CML 7

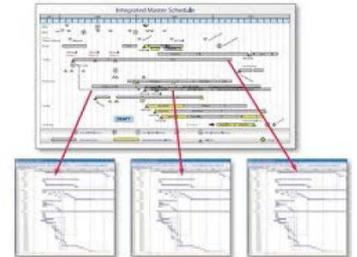
CML 8

$F=ma$

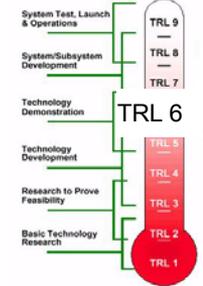
Initial Feasibility



Point Design



Integrated Concept



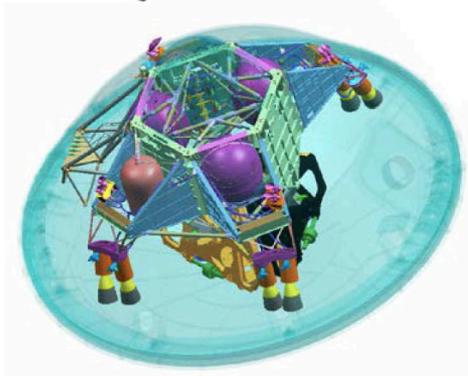
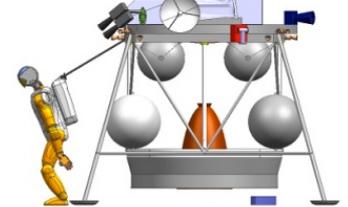
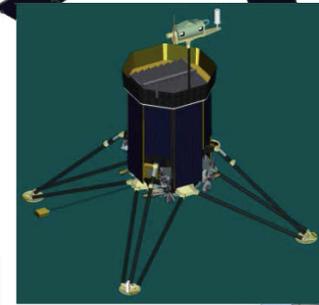
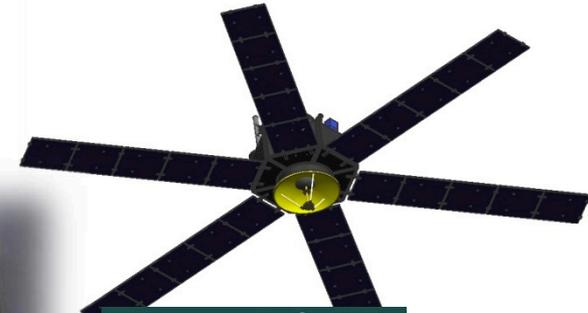
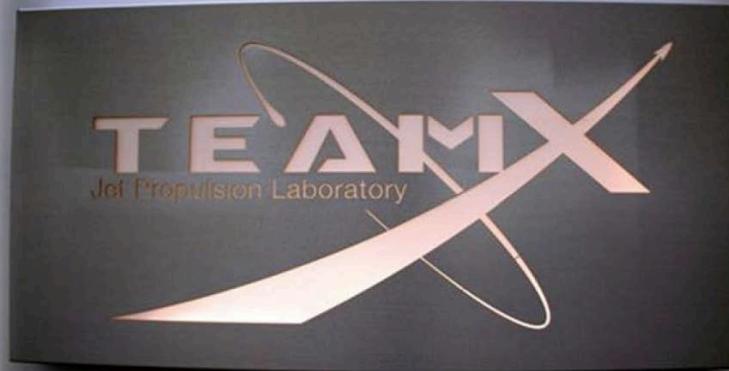
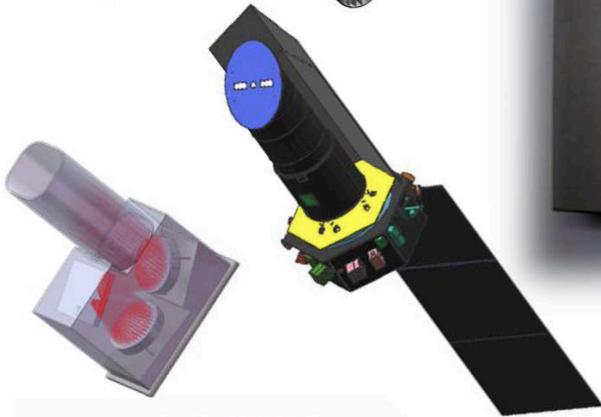
Integrated Baseline



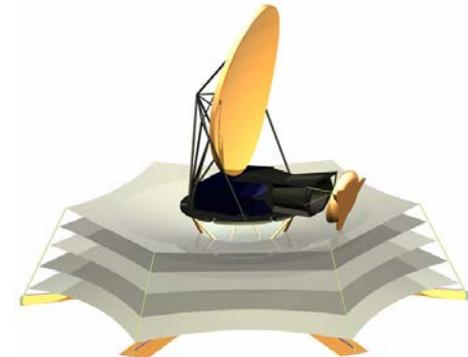
Team X pioneered CE for CML 4



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- Architectures
- Space Missions
- Flight Systems
- Instruments



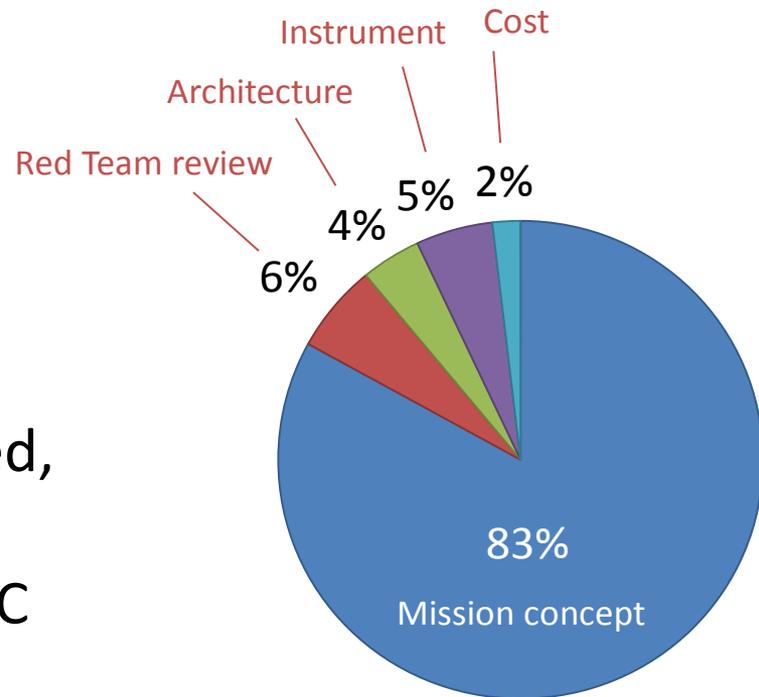


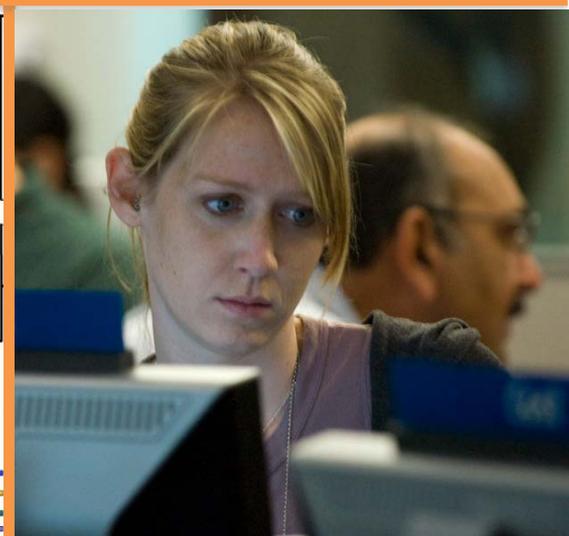
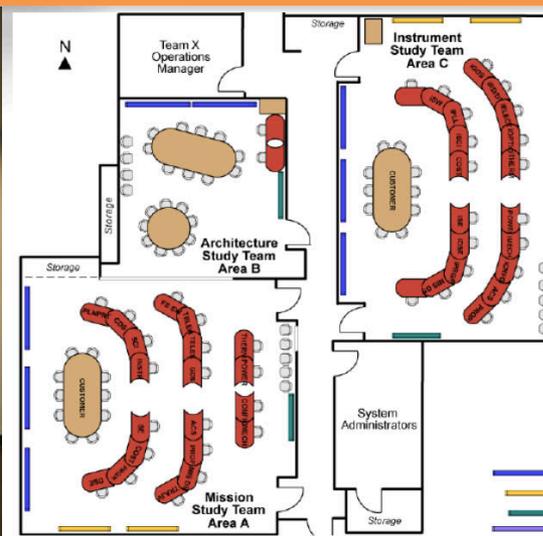
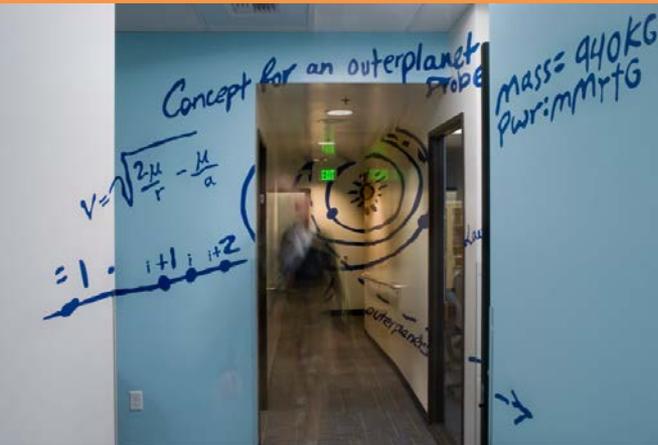
Team X: Widely Emulated

- 1072 studies since creation in 1995
Peak rate was 93 studies per year (2004)
- Drivers going forward

Increasing concept diversity challenges design-model applicability

Increasing need for customized, direct-use products (white papers, proposal sections, NRC reports)



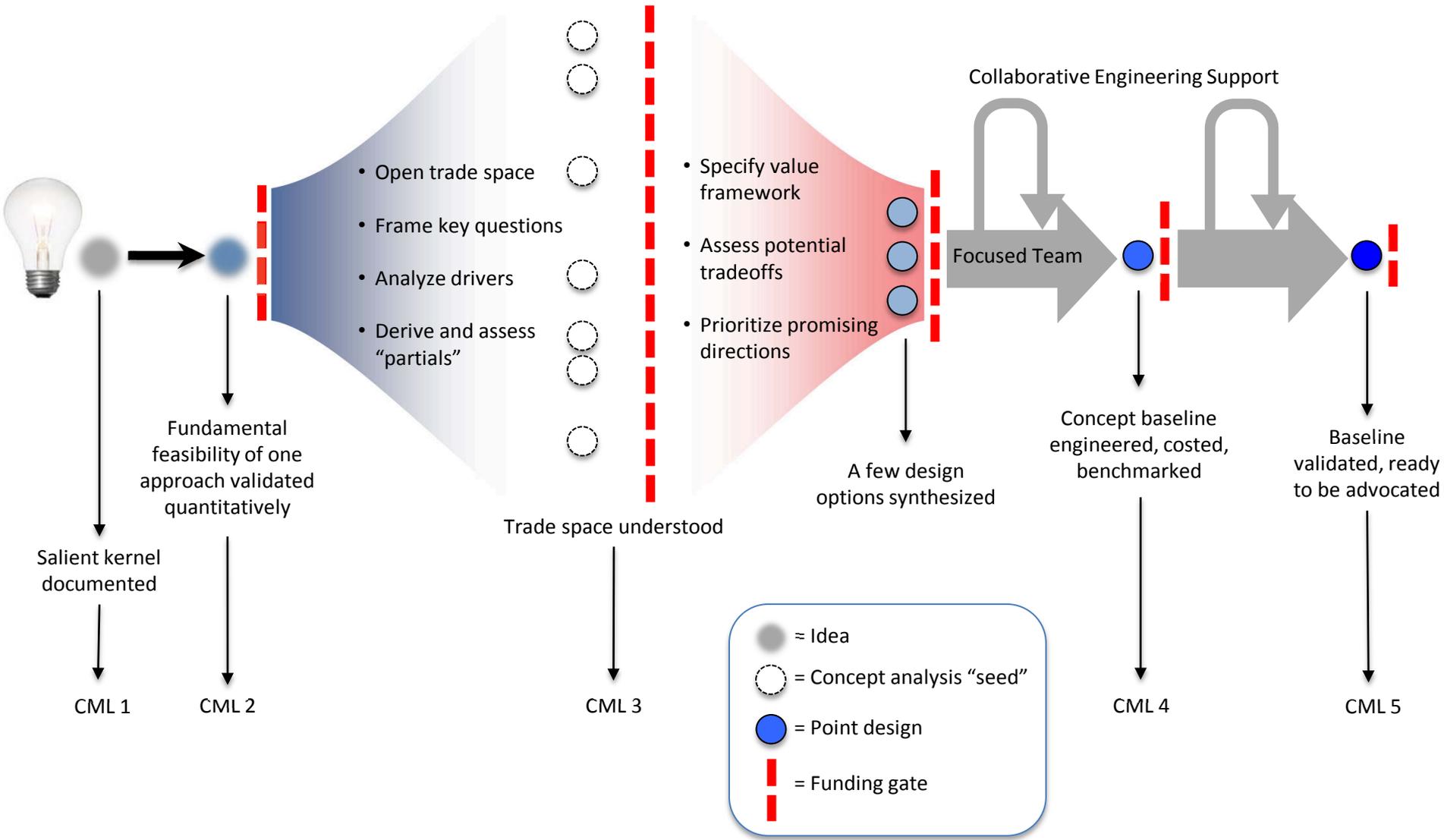




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Evolving Ideas *Before* CML 4

Next-gen CE at JPL





A-Team: New Type of CE for CML 1-3

A-Team Type	Purpose
Generate Ideas	Produce and organize 10^2 ideas from a single question or topic. Rank using figures of merit.
Assess Feasibility	Quantitative, tool-based examination of technical and programmatic feasibility
Explore Architecture Trade Space	Develop and use “concept analysis seeds” to expose gradients in the trade space
Science Traceability	Link science questions to goals, objectives, observables, measurements, and instruments
Technology Impact	Ideate potential applications, assess feasibility, quantify science-mission and architecture impacts
Strategic Opportunities	Quick-focus on one strategic question. Analyze potential ROI, develop forward plan.

In high demand: 39 studies in 1.5 years so far



A-Team allows study of high-leverage, open-ended ideas not ready for Team X

