Integrated Product Design Simulation

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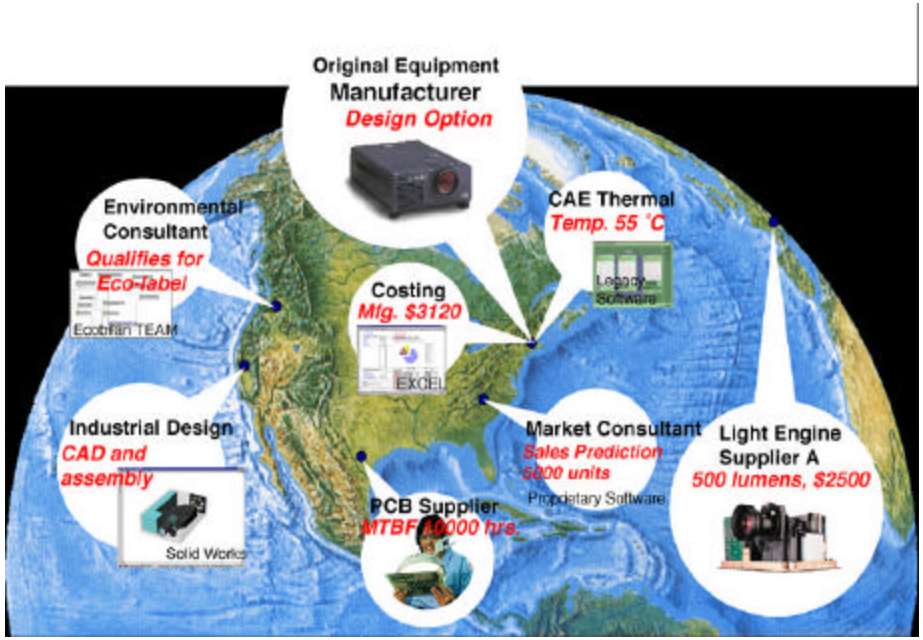
DOME (distributed object-based modeling environment)



Publications: http://cadlab.mit.edu

Integrated Product Design Simulation

Outline

Design context

Need

Concept

Scenario

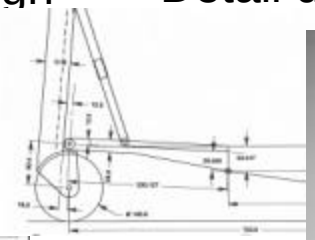
Barriers addressed

Applications

Product Design

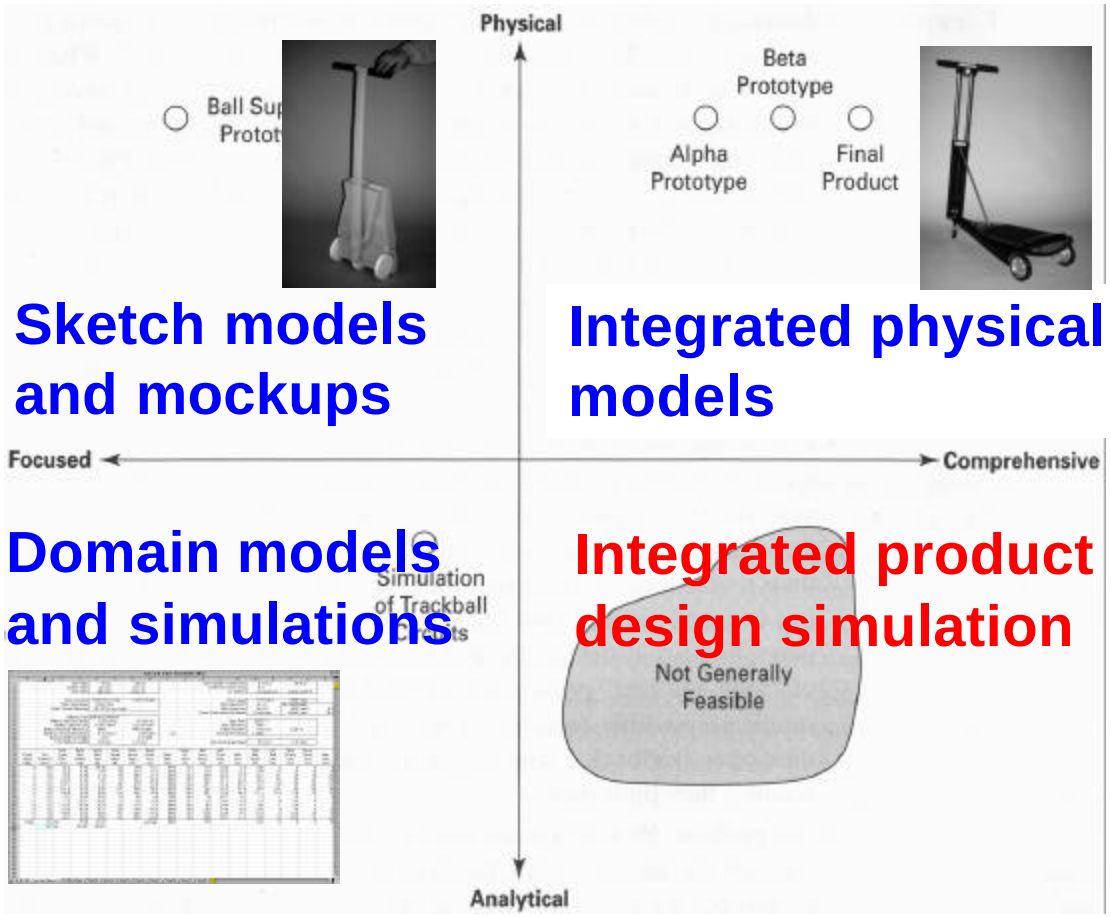
Modeling context

Planning | Concept design | Detail design | Testing | Ramp up



Design Modeling

Techniques



From: Ulrich and Eppinger,Product design and development, 2000

Need

Integrated system modeling and simulation

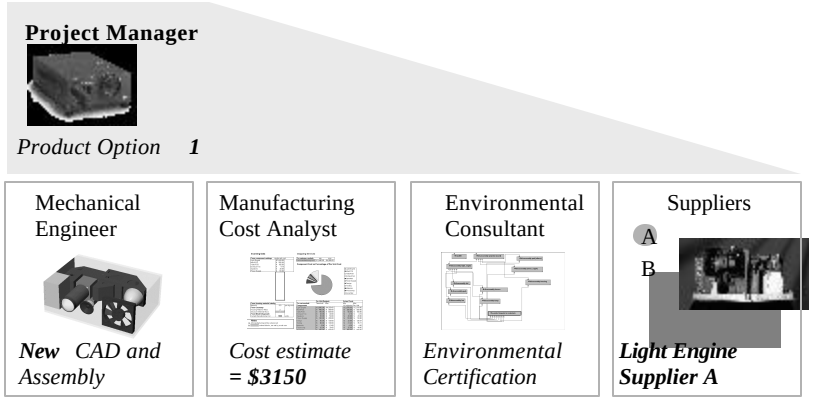
Mathematically predict and analyze the integrated behavior of products throughout the pre-prototype design cycle

Benefits

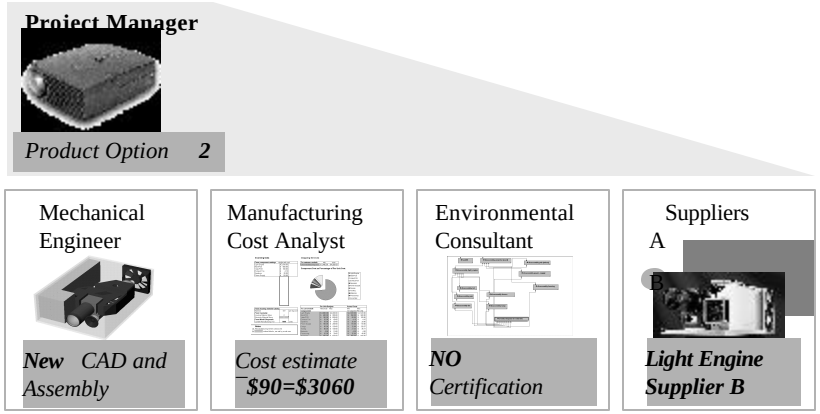
Simulation-based integrated system analysis

Polaroid LCD projector

Seamless mathematical integration:
geometry, engineering,
life-cycle analysis,
customer and
intent-to-purchase simulations



Result:
integrated trade-off
cycle time reduced
from 3 months to
15 seconds



"not generally feasible"

Hypothesis

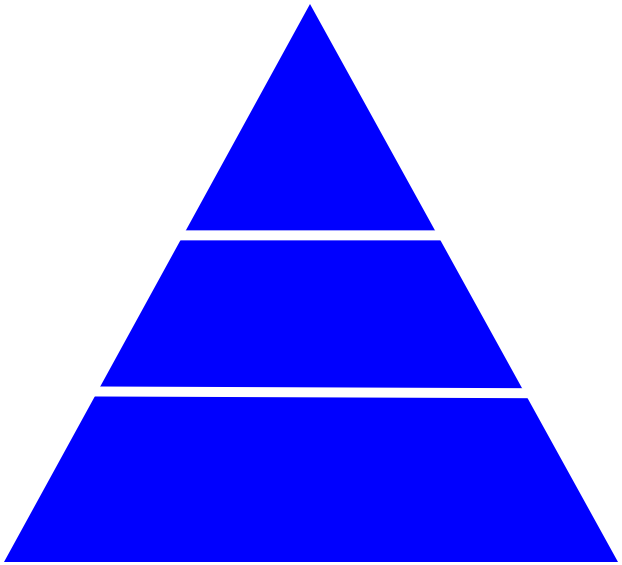
Limitation is simulation synthesis, not analysis

Mathematical system modeling techniques do not match design synthesis needs

Mismatch

Traditional model integration methods

Explicit, fixed scope, command and control



Implicit, emergent

Existing methods do not accommodate flexible model growth, change, emergence, or rapid transitions between synthesis and analysis

Synthesis Mismatch

Consequences

Infeasible because of design ...

complexity, scale, rate of change

heterogeneity

proprietary knowledge

Cutkosky, 1996

DOME

Research goal

A new infrastructure for building the integrated simulations needed in design analysis

Fundamentally resolve traditional integration barriers

Future Design

Engineering emergent systems

DOME Inspiration

Hypertext (WWW)

Revolution in infrastructure for building information networks—breaking control barriers

Any individual can add content

Any individual can access remote material and create local links to relevant materials

Result: an emergent network of information services

DOME Concept

World-wide Simulation Web

Any individual can make interfaces to focused simulations operable over the Internet

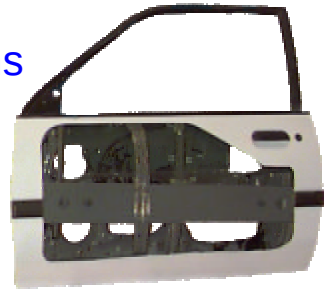
Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

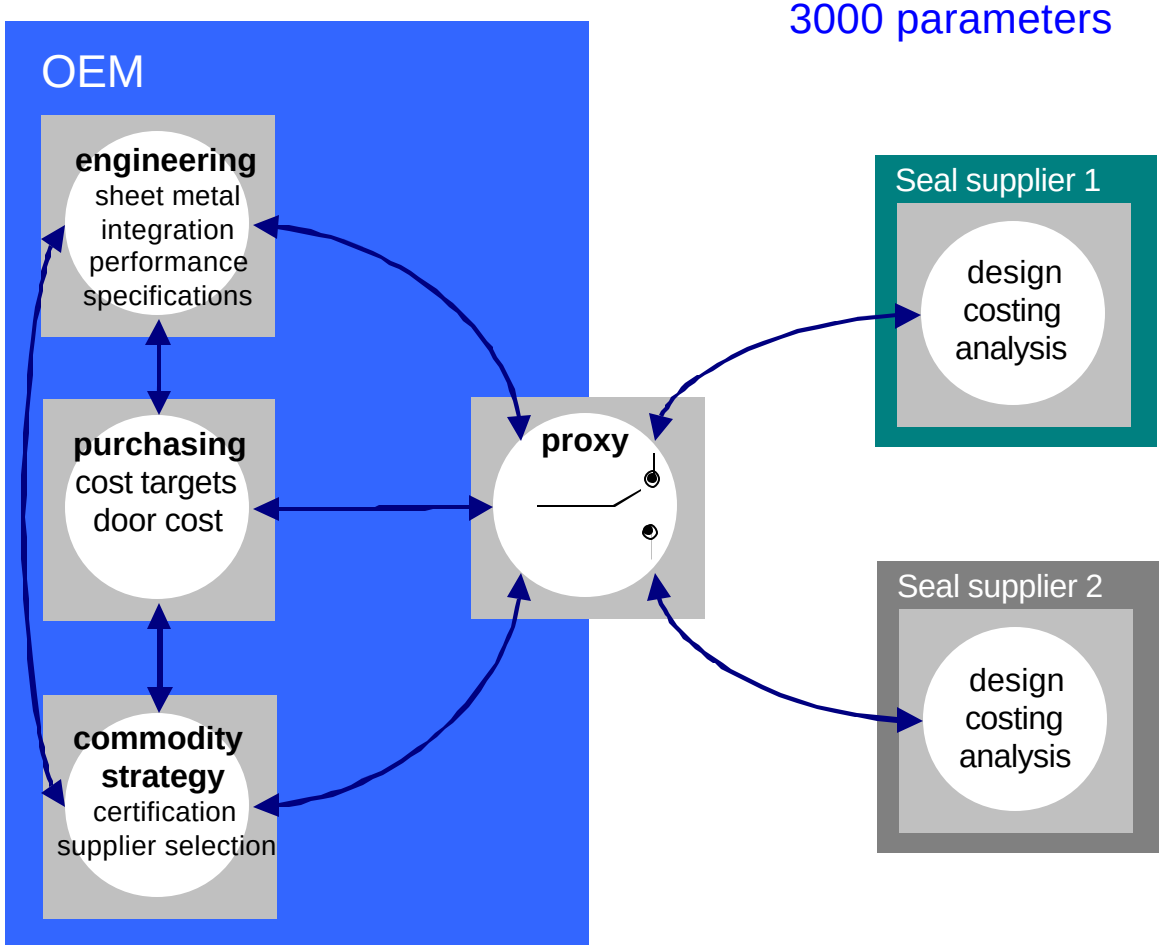
Result: an emergent network of parametrically coordinated simulations

DOME Application

Proof of concept field study

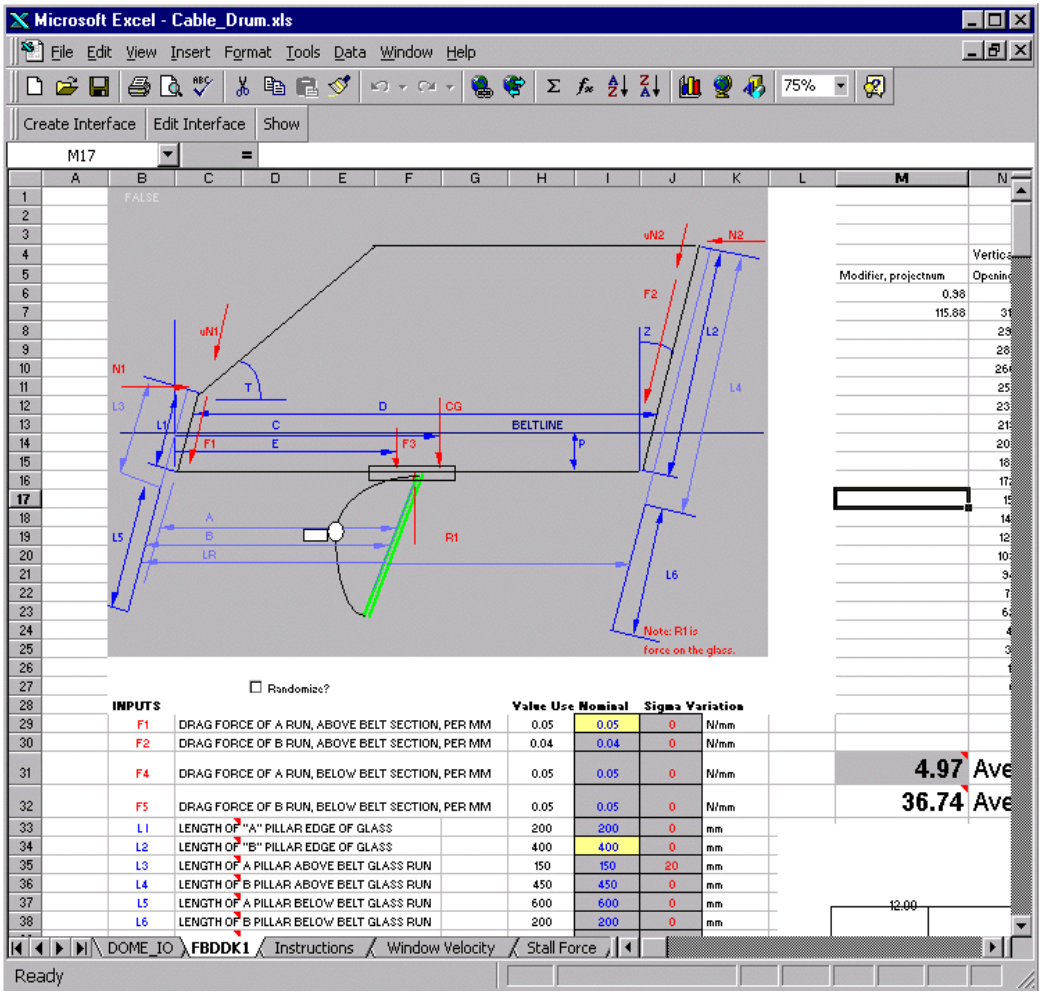
21 external simulations
3000 parameters





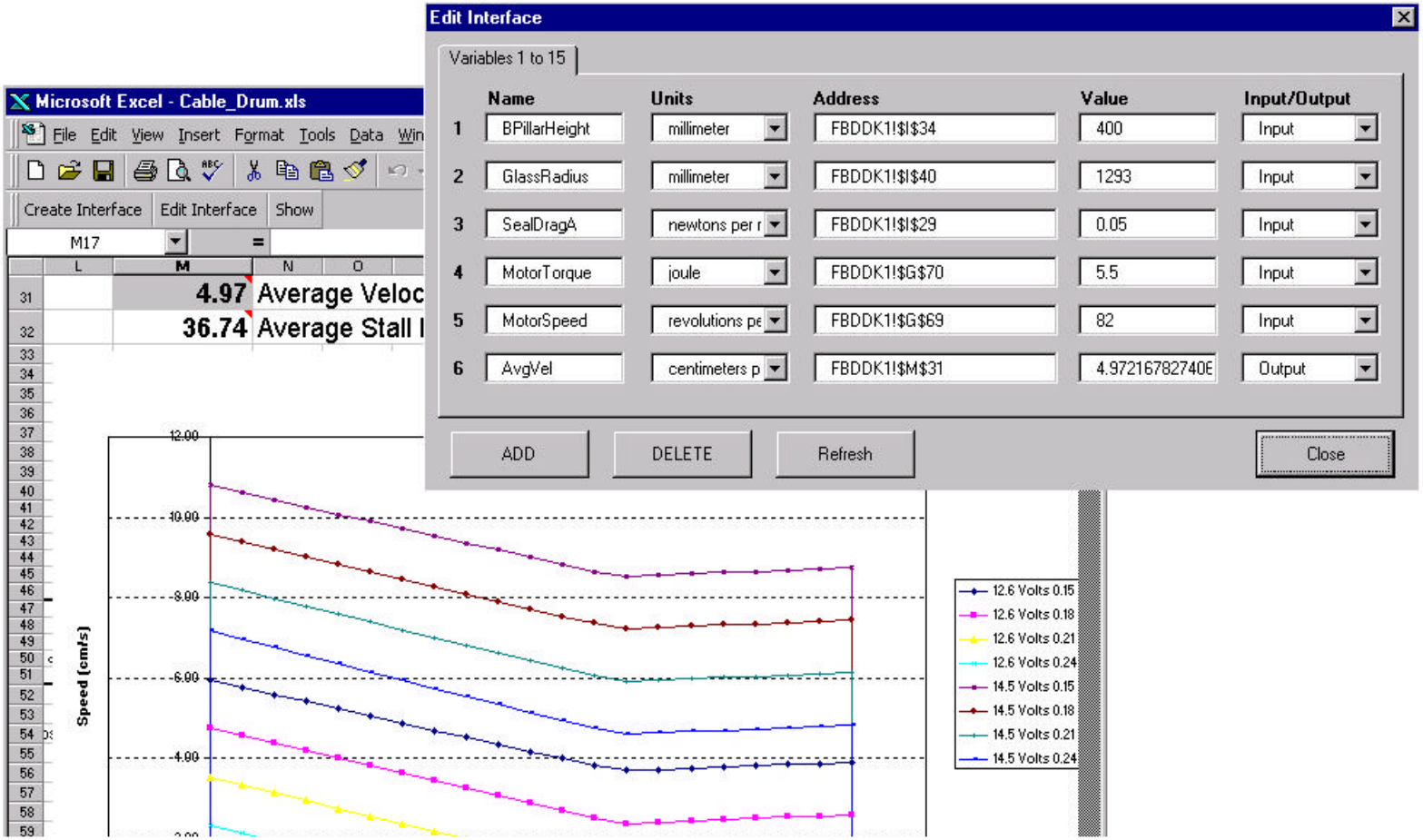
Integrated Simulation Synthesis

Participants build models using tools appropriate for their discipline



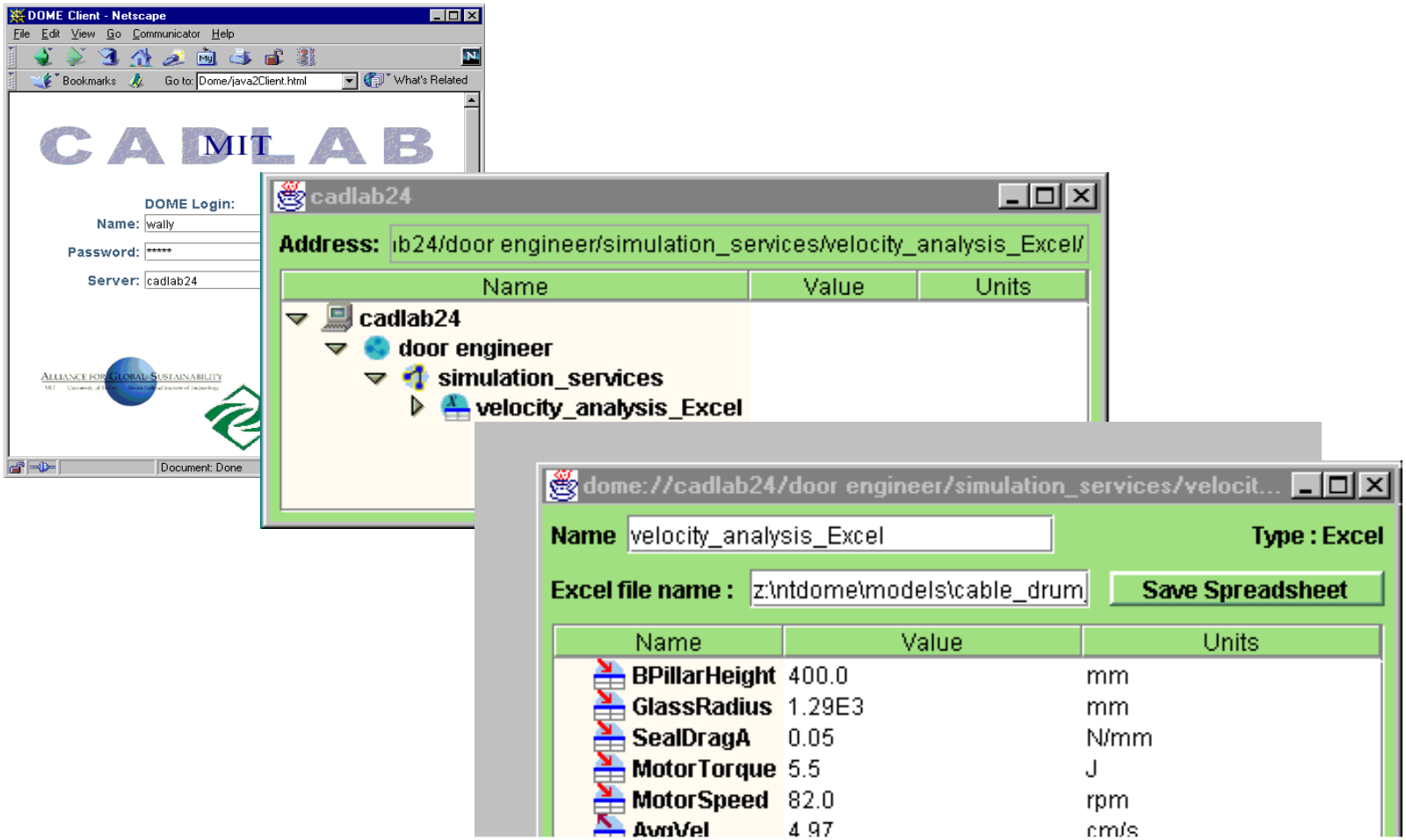
Integrated Simulation Synthesis

Participants define parametric interfaces to their focused simulations



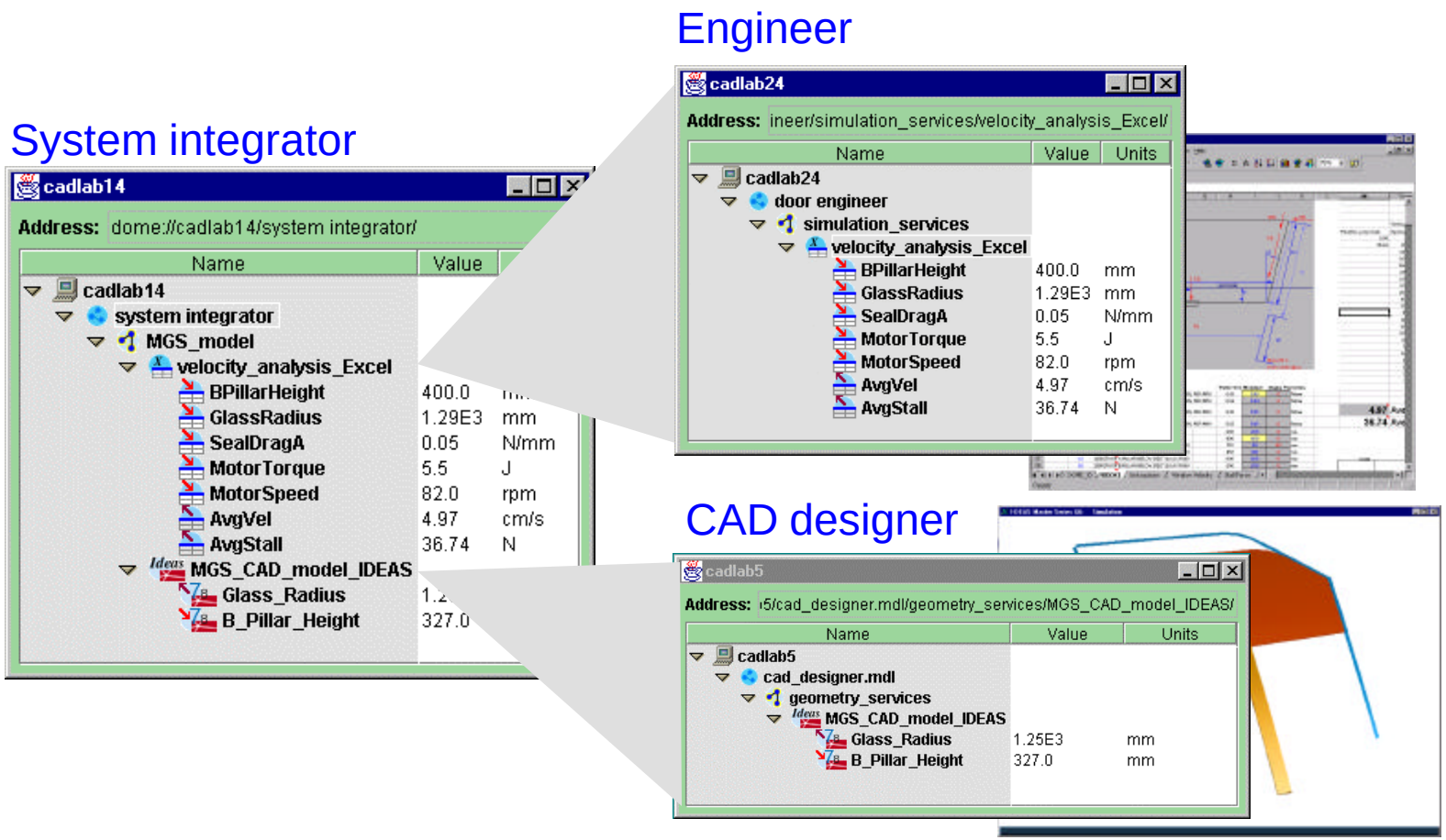
Integrated Simulation Synthesis

Participants deploy interfaces on Internet-accessible DOME servers



Integrated Simulation Synthesis

Participants create DOME bridge models between interface elements



New Integration Infrastructure

World-wide Simulation Web

Any individual can make interfaces to focused simulations operable over the Internet

Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

A domain independent simulation infrastructure

Integrated System *Analysis*

Participants apply tools to elucidate tradeoffs, optimize designs, and understand system interactions

Examples:

Decision theory (Kim and Wallace, 1999)

Genetic optimization (Gruininger, Senin and Wallace, 1996)

System structure analysis (Abrahamson and Wallace, 1999)

Model customization (Ferara and Wallace, in progress)

Ford Application

Results

Rapid system model development and evolution

(Integration process was 12 person days)

Interoperability of services between heterogeneous applications without sharing proprietary data models

Design tradeoff speed

(Ford engineer to supplier analyst: 10s *vs.* ~2 weeks)

Rapid design comparison of local design and supplier changes with global tradeoff viewpoint

New Integration Infrastructure

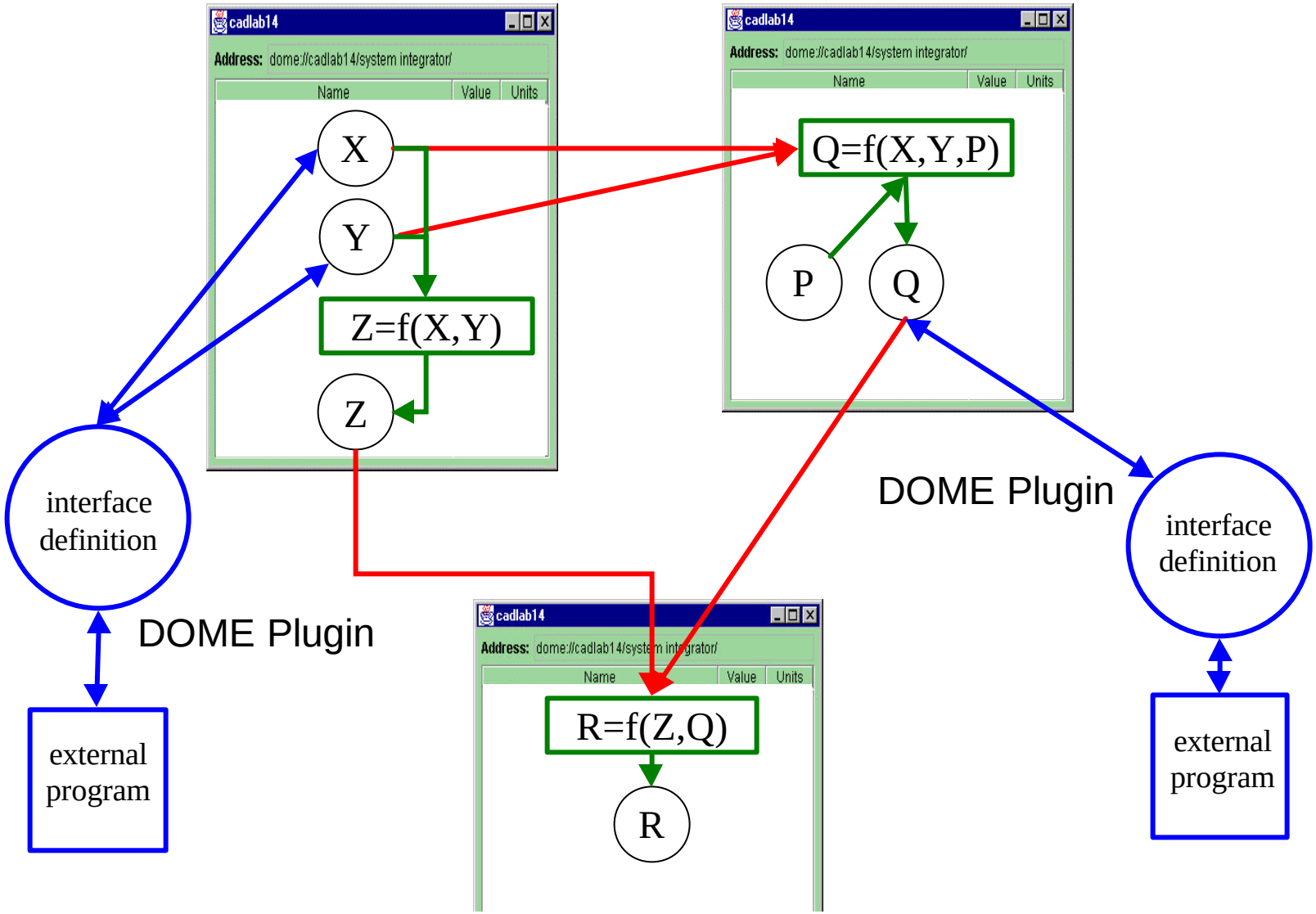
Fundamentally resolve traditional integration barriers

Complexity, scale, rate of change

Emergent *vs.* explicit system definition

New Integration Infrastructure

Localized definition of interfaces and relationships

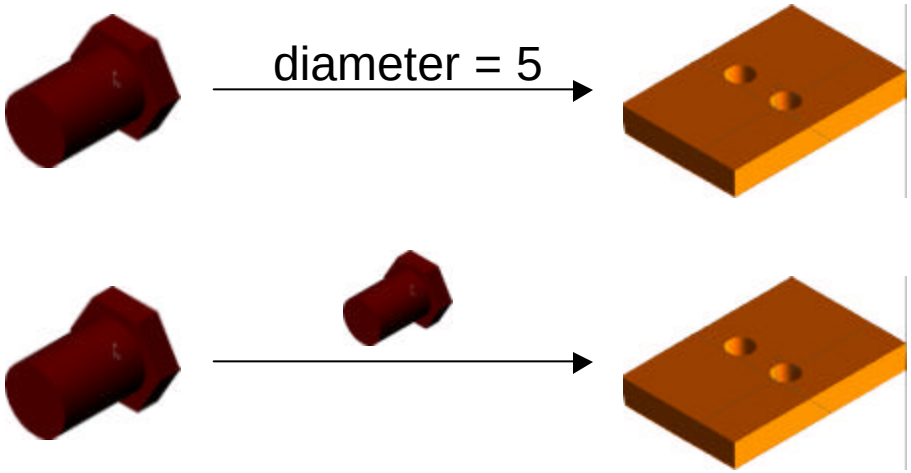


New Integration Infrastructure

Fundamentally resolve traditional integration barriers

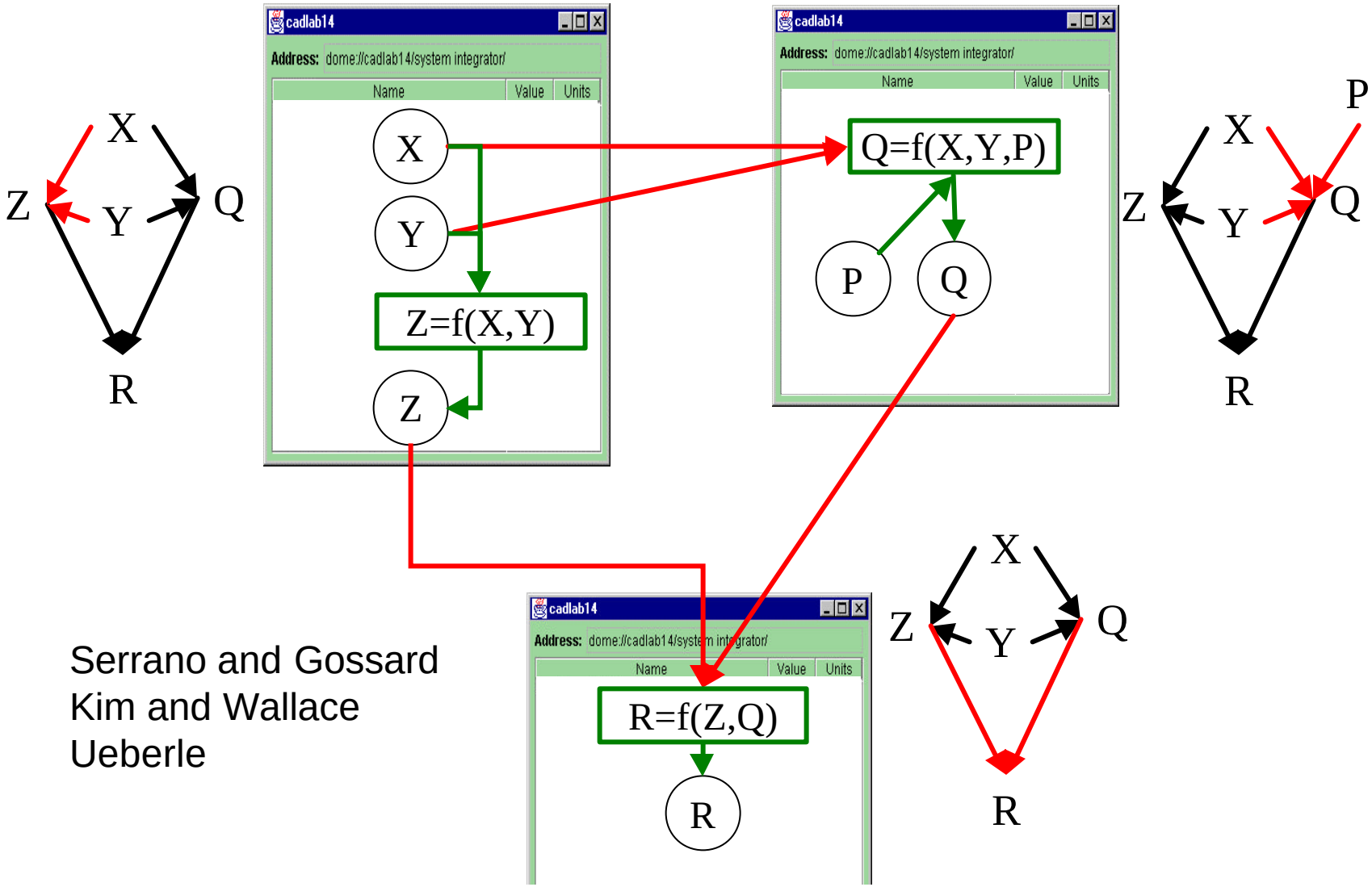
Heterogeneity, proprietary information

Parametric consistency *vs*. data model sharing



New Integration Infrastructure

Local solvers share causal mapping for externally accessible interface parameters



Serrano and Gossard
Kim and Wallace
Ueberle

Industry Pilot Applications

Recently completed or ongoing

Organization	Project
Ford	Door glass system Integrated simulation across the design/supply chain
Ford	Fuel economy Integrated technology assessment
Ford	Vehicle platform design Parametric assemblies with multiple CAD systems
LG Electronics	Air conditioner design Platform management
Boeing	New materials adoption Integrated simulation across length scales
US Navy	Aircraft carrier ordinance delivery Life-cycle cost reduction

Vehicle Platform Application

Geometric assemblies

Traditional integration approach:

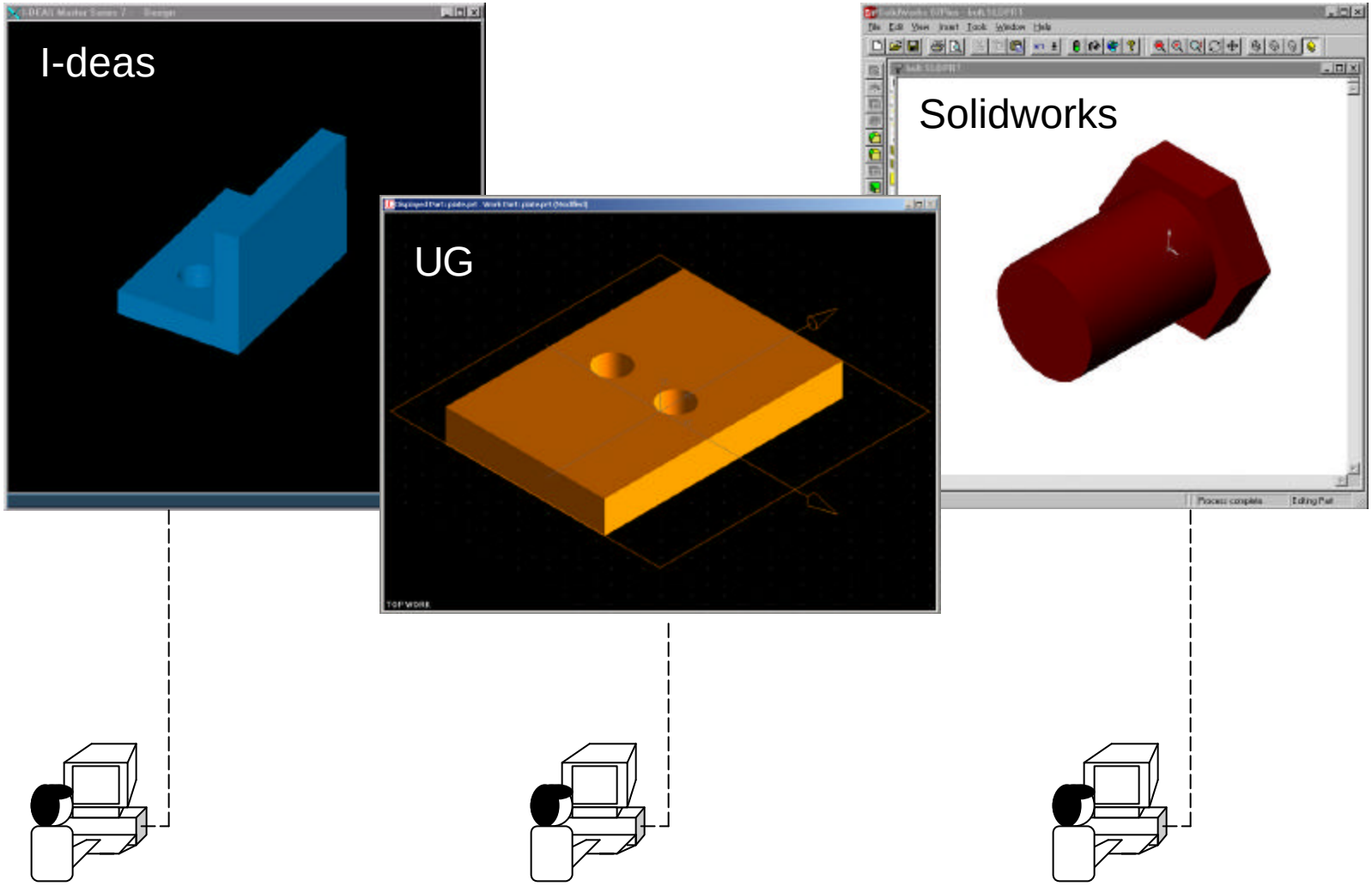
Each company has an official CAD system

All suppliers must use the official CAD system

Suppliers must provide native part geometry to automotive company

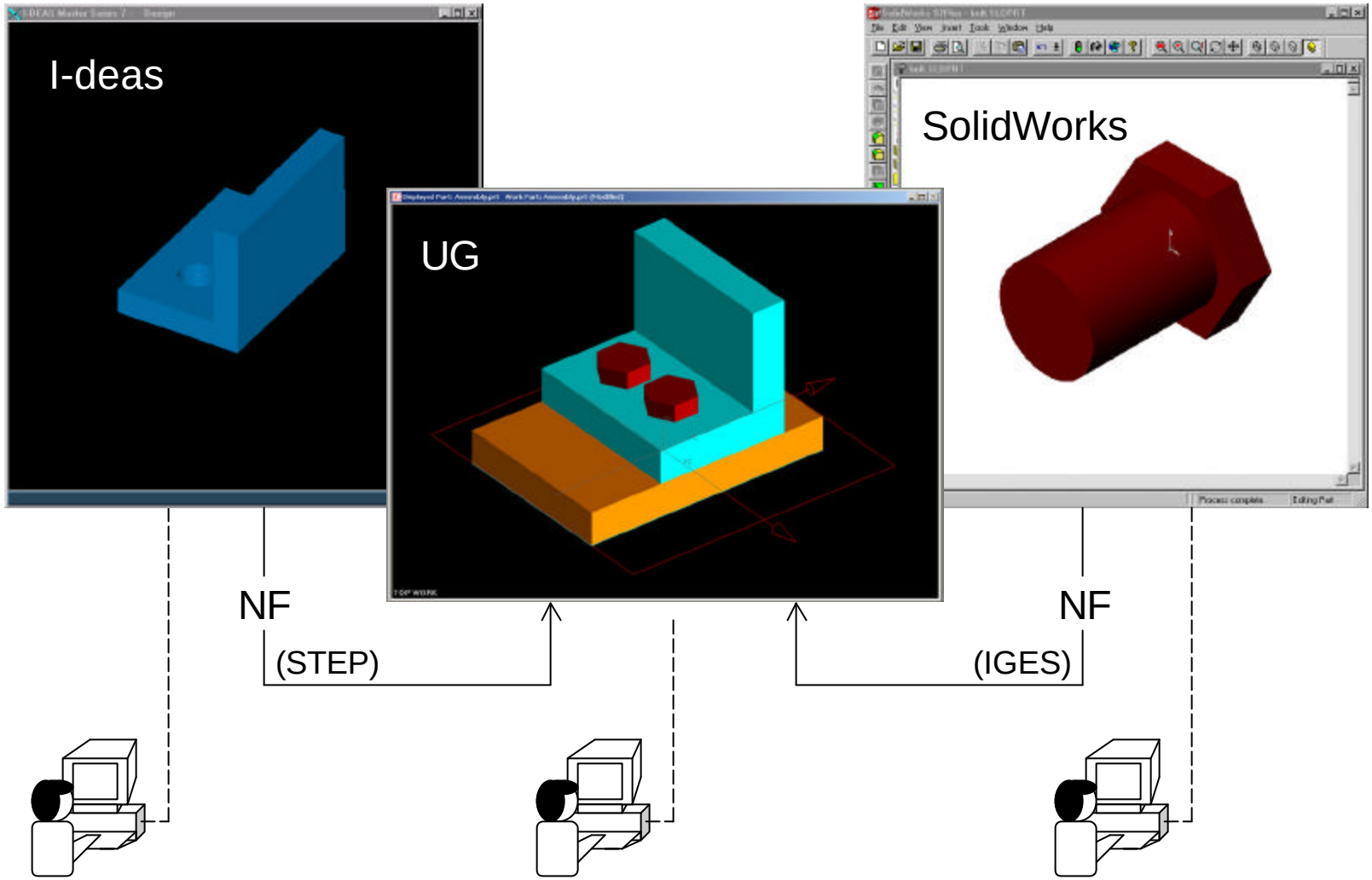
Vehicle Platform Application

Parametrically editable assemblies



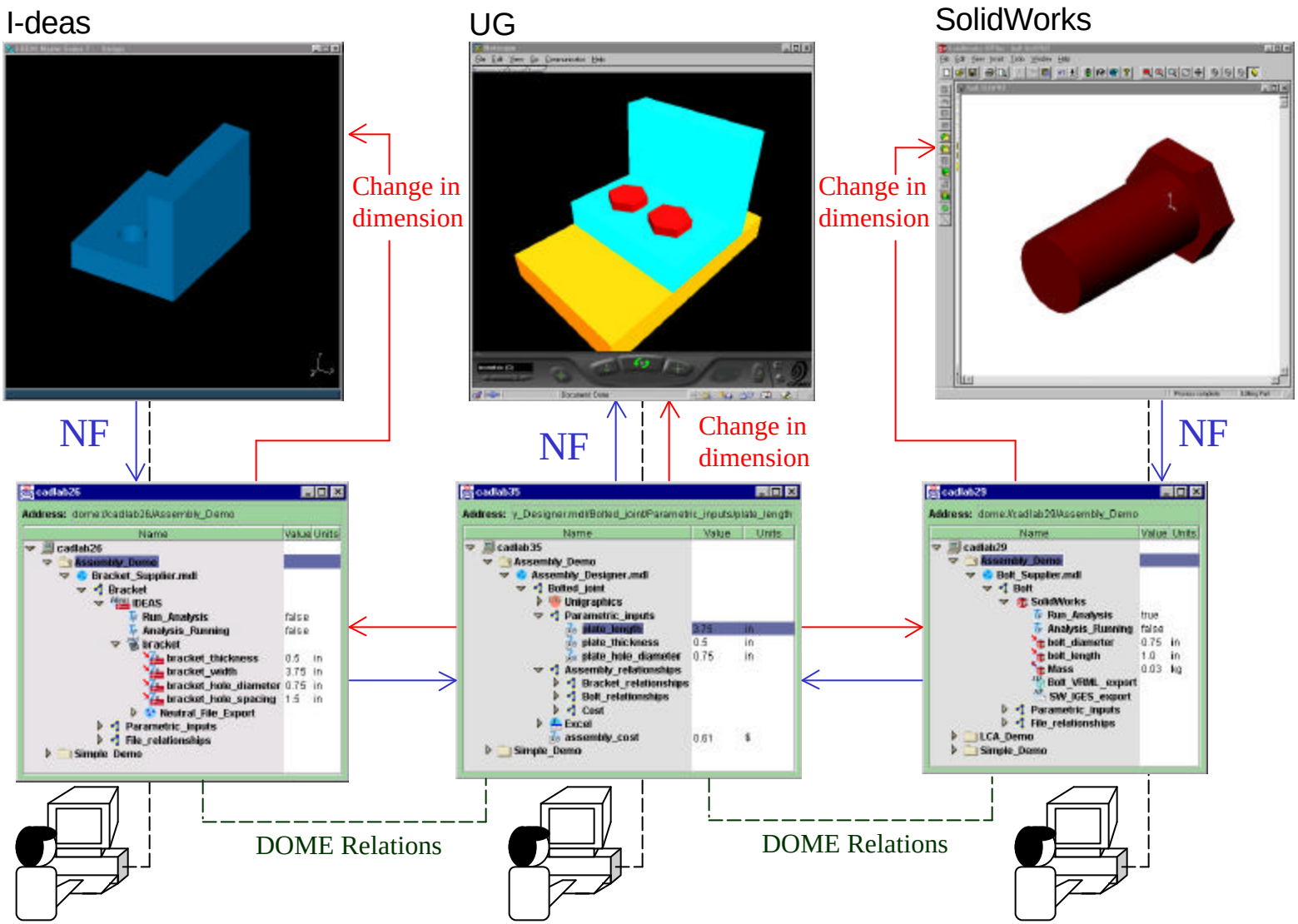
Vehicle Platform Application

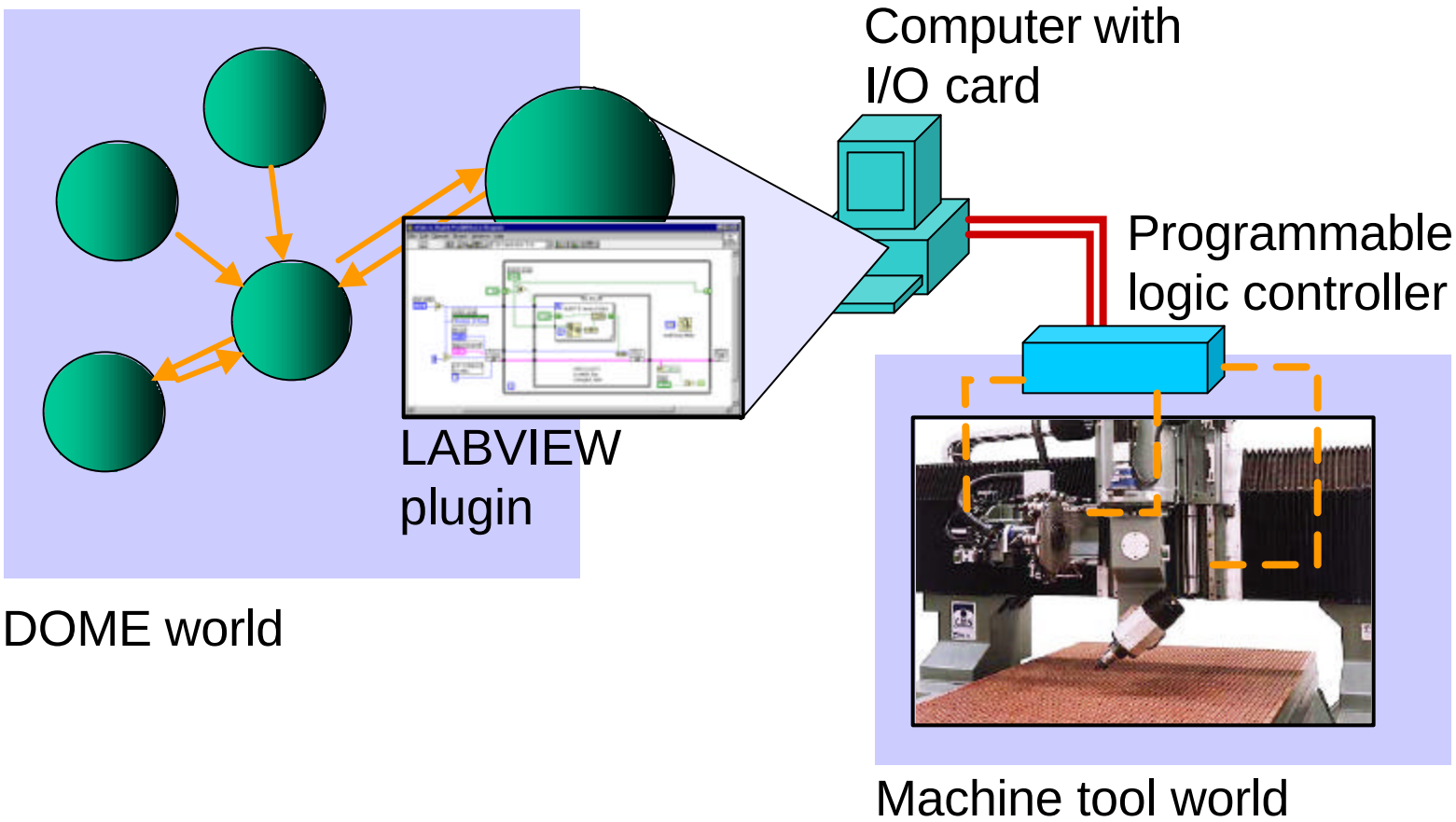
Parametrically editable assemblies



Vehicle Platform Application

Parametrically editable assemblies



Application

Manufacturing object module: MOM