

Integrated Product Design Simulation

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DOME (distributed
object-based modeling
environment)



Publications: <http://cadlab.mit.edu>

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Classification of Abstract unclassified	Limitation of Abstract UU	
Number of Pages 31		

design context

need

concept

scenario

barriers

application

Integrated Product Design Simulation

Outline

Design context

Need

Concept

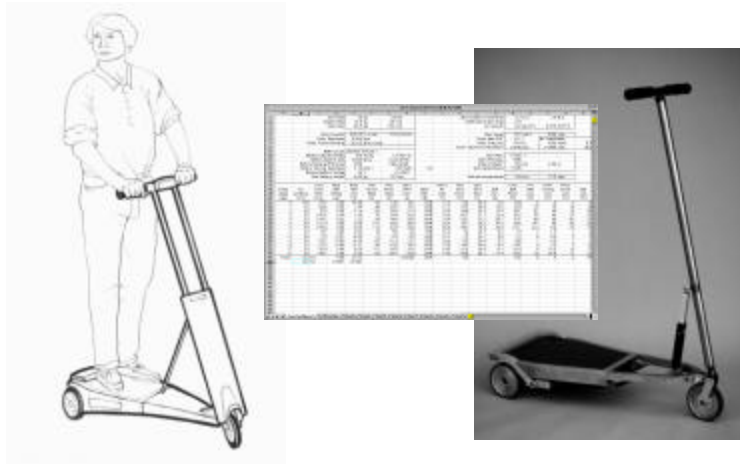
Scenario

Barriers addressed

Applications

Product Design

Modeling context

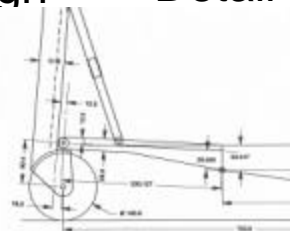


Planning

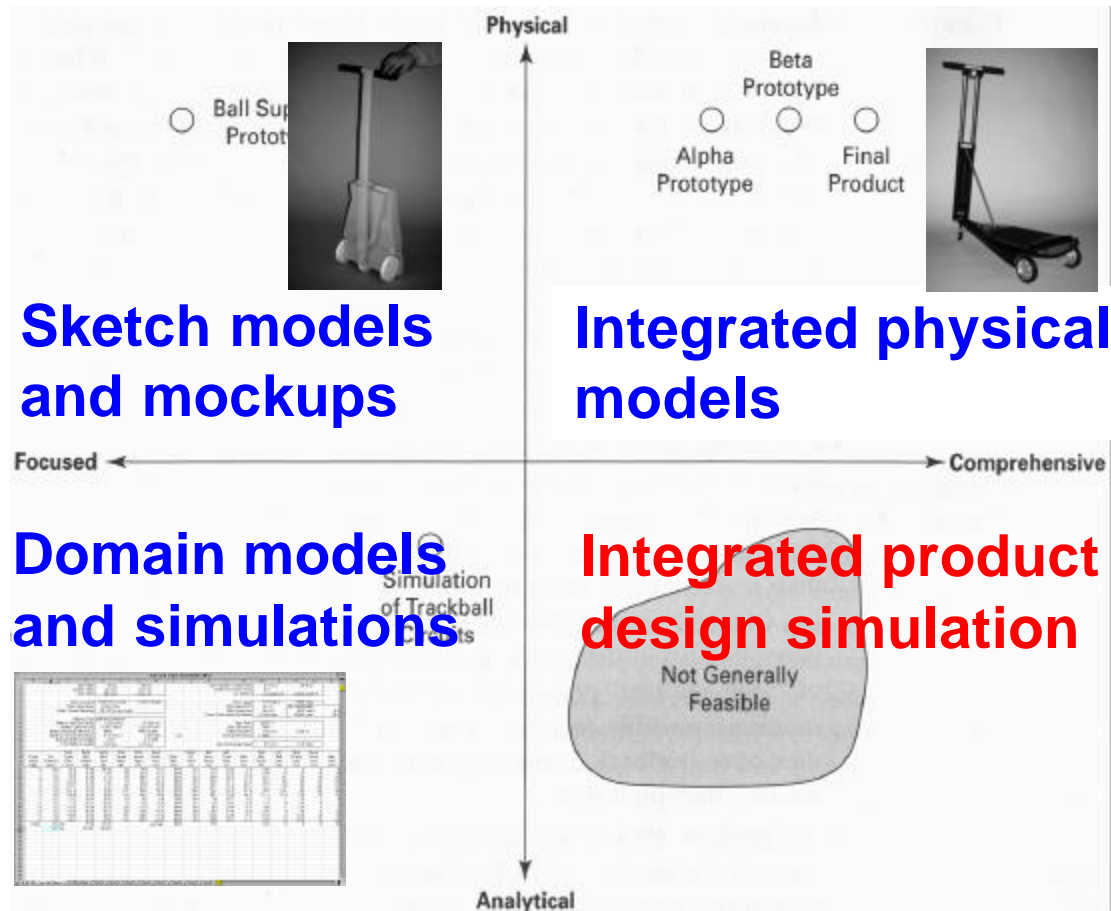
Concept design

Detail design

Testing Ramp up



Design Modeling Techniques



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

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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

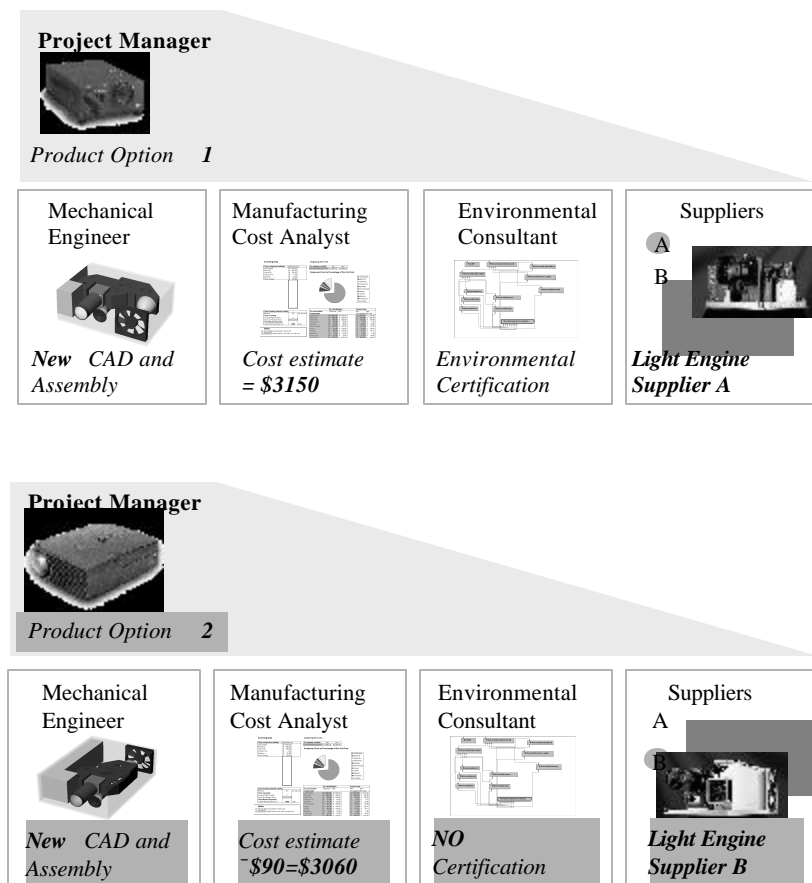
Seamless mathematical integration:

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”



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Hypothesis

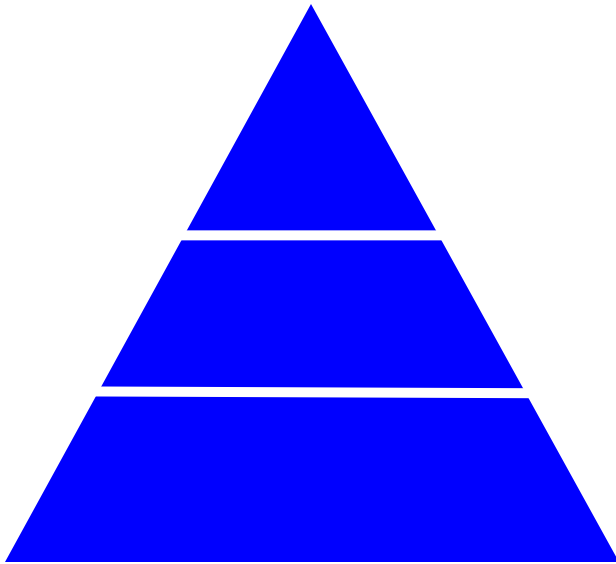
Limitation is simulation synthesis, not analysis

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 ...

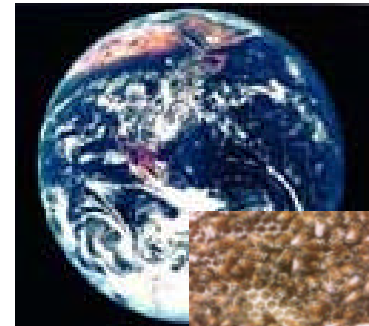


complexity, scale, rate of change

heterogeneity

proprietary knowledge

Cutkosky, 1996



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DOME

Research goal

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

Fundamentally resolve traditional integration barriers

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Future Design

Engineering emergent systems

product



infrastructure



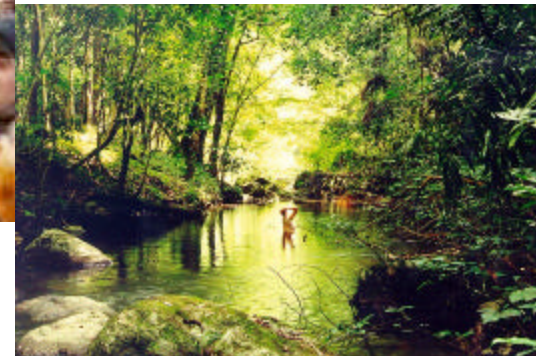
urban environment



society



sustainability



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

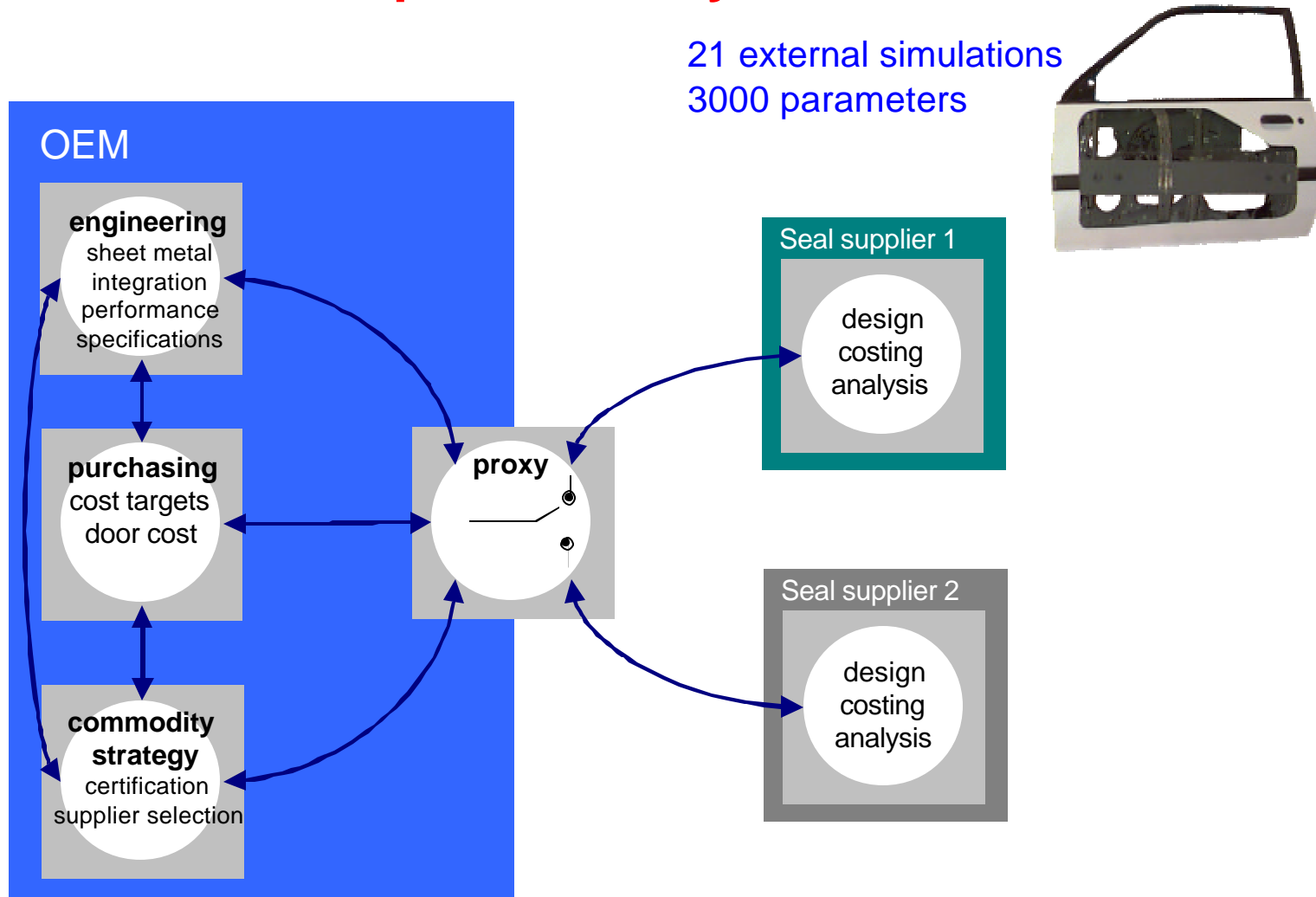
Any individual can make interfaces to focused simulations operable over the Internet

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

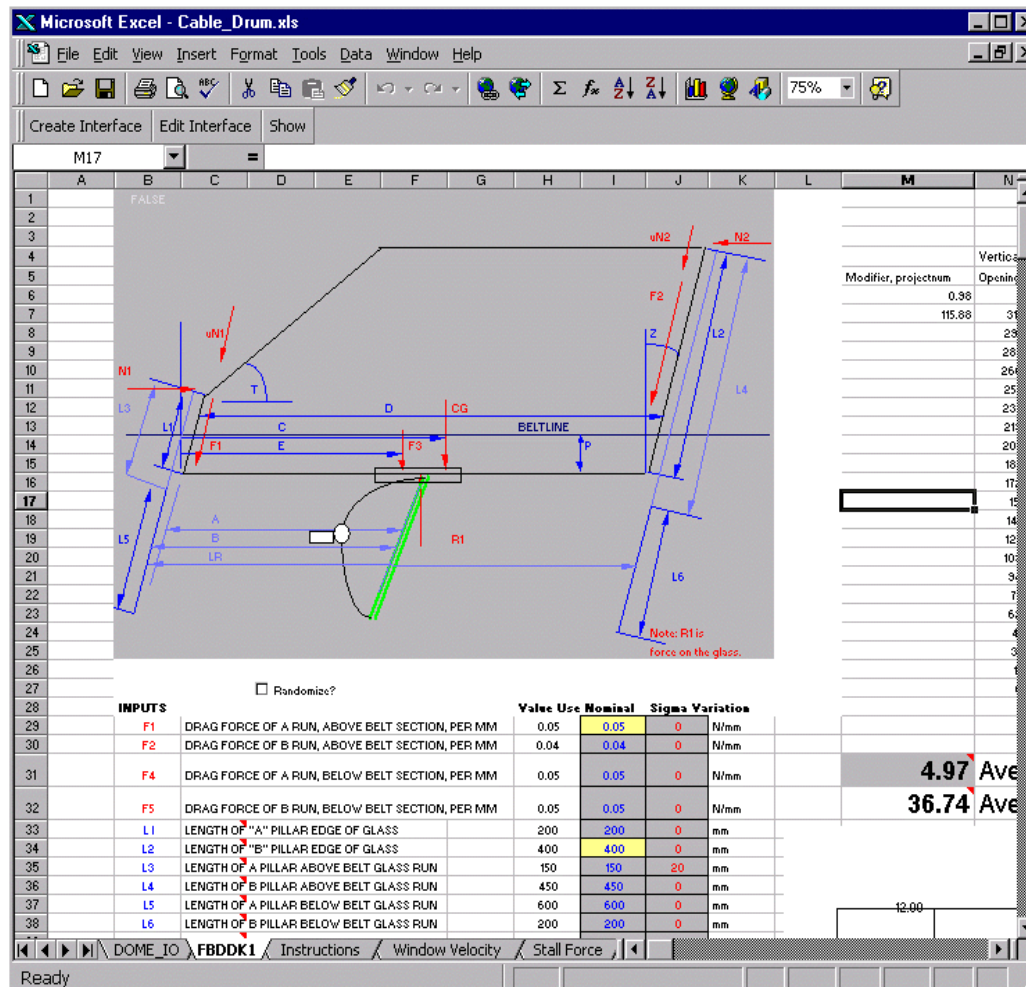
DOME Application

Proof of concept field study



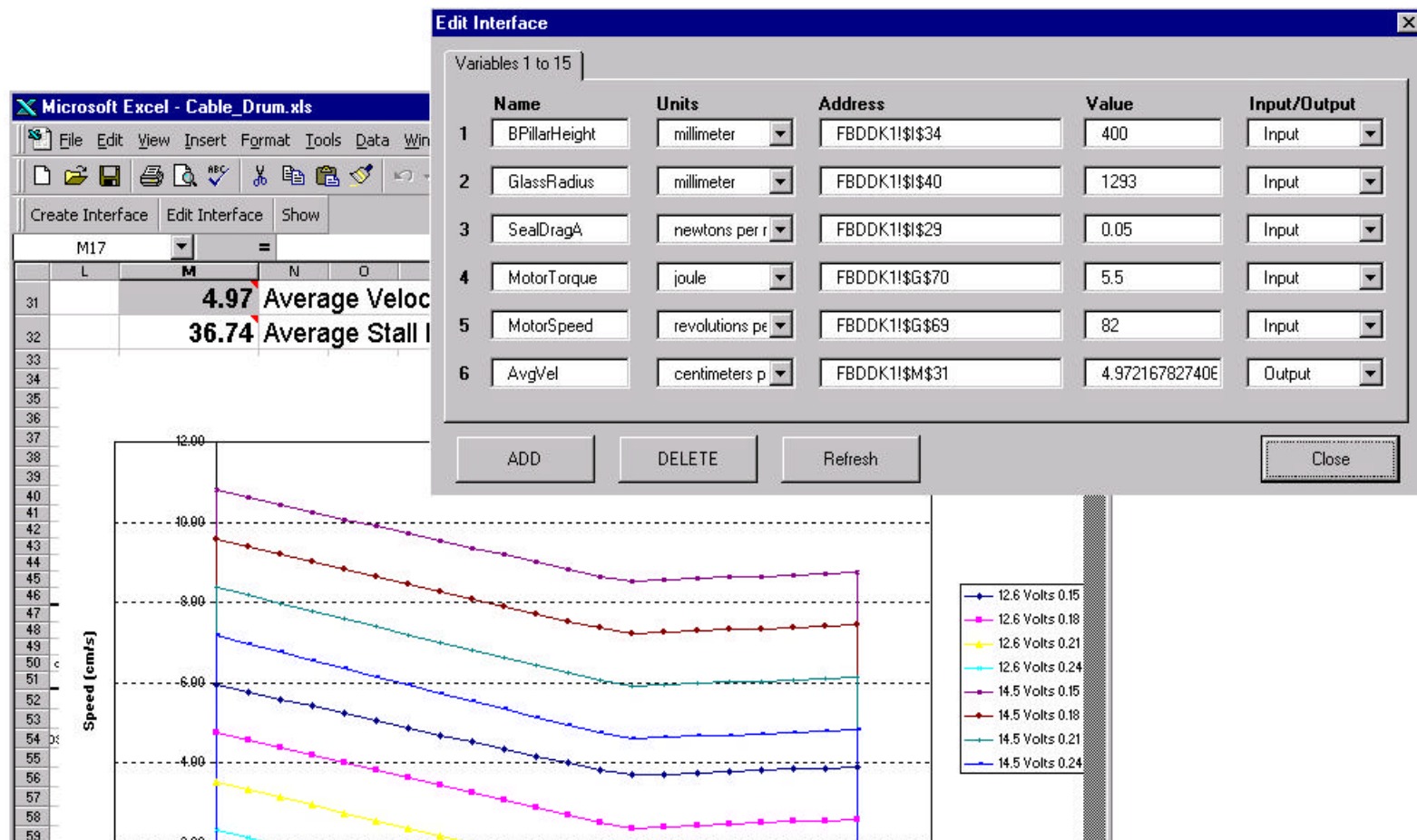
Integrated Simulation Synthesis

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

DOME Client - Netscape

File Edit View Go Communicator Help

Go to: Dome/java2Client.html

CADLAB

DOME Login:

Name: wally

Password: *****

Server: cadlab24

ALLIANCE FOR GLOBAL SUSTAINABILITY
MIT University of Massachusetts Lowell

cadlab24

Address: ib24/door engineer/simulation_services/velocity_analysis_Excel/

Name	Value	Units
cadlab24		
door engineer		
simulation_services		
velocity_analysis_Excel		

dome://cadlab24/door engineer/simulation_services/velocit...

Name: velocity_analysis_Excel Type: Excel

Excel file name: z:\ntdome\models\cable_drum Save Spreadsheet

Name	Value	Units
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvnVel	4.97	cm/s

Integrated Simulation Synthesis

Participants create DOME bridge models between interface elements

Engineer

System integrator

Name	Value	Units
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvgVel	4.97	cm/s
AvgStall	36.74	N

Name	Value	Units
BPillarHeight	400.0	mm
GlassRadius	1.29E3	mm
SealDragA	0.05	N/mm
MotorTorque	5.5	J
MotorSpeed	82.0	rpm
AvgVel	4.97	cm/s
AvgStall	36.74	N

CAD designer

Name	Value	Units
Glass_Radius	1.25E3	mm
B_Pillar_Height	327.0	mm

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

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New Integration Infrastructure

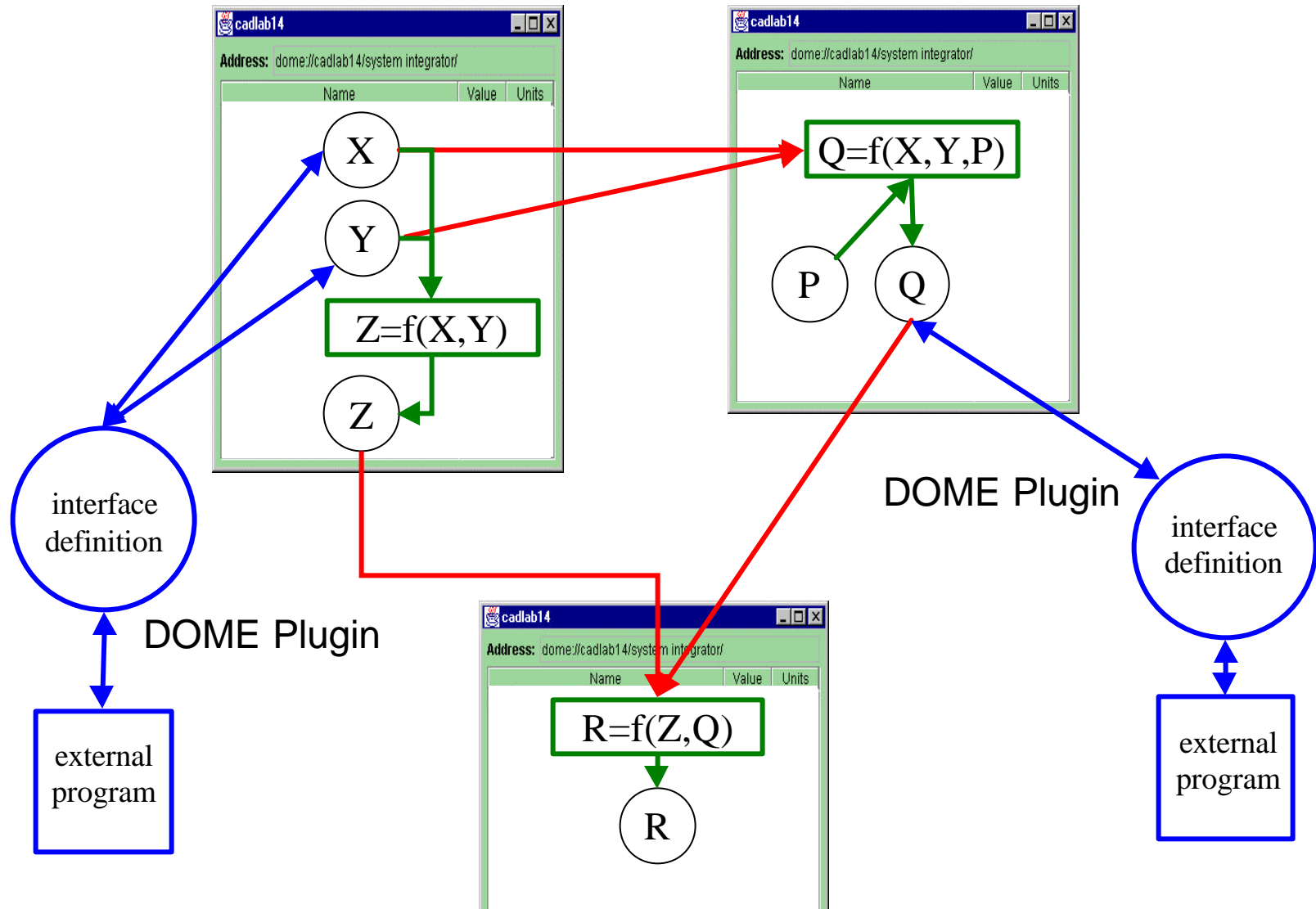
Fundamentally resolve traditional integration barriers

Complexity, scale, rate of change

Emergent vs. explicit system definition

New Integration Infrastructure

Localized definition of interfaces and relationships

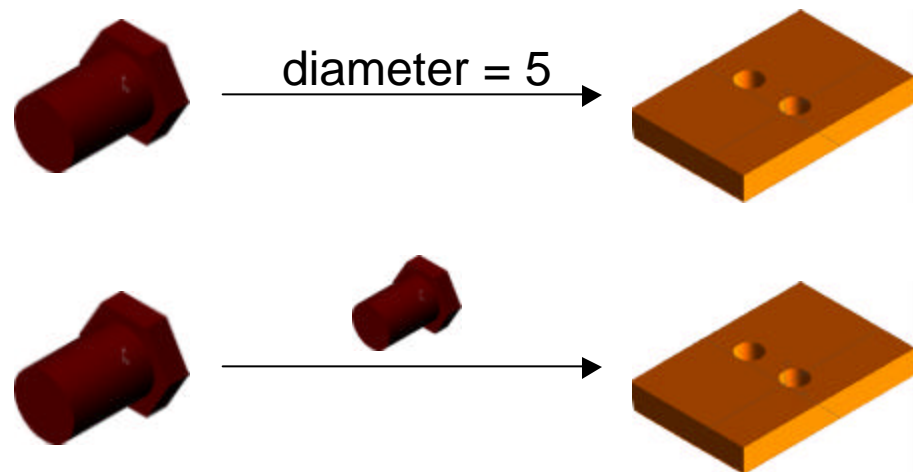


New Integration Infrastructure

Fundamentally resolve traditional integration barriers

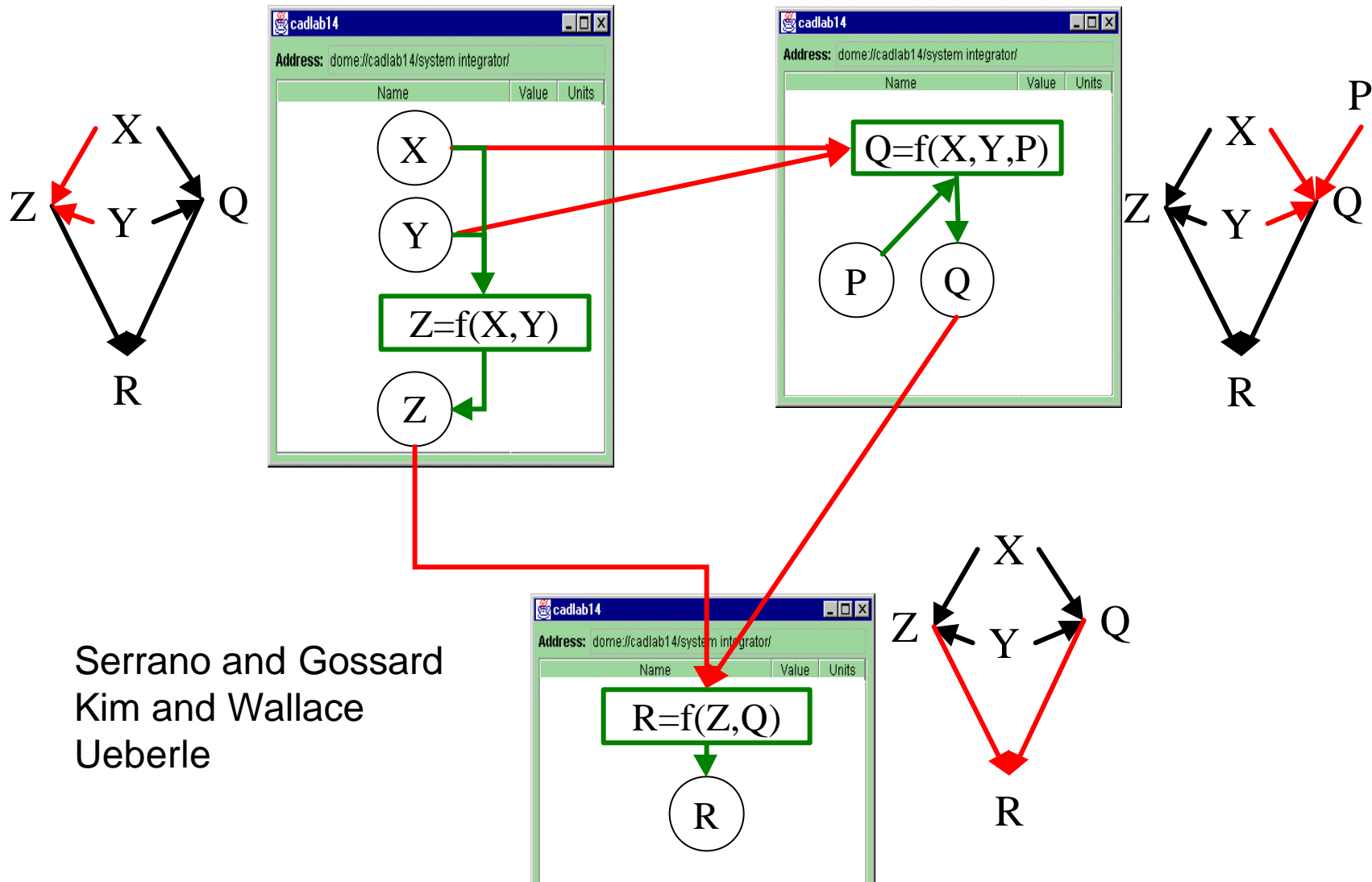
Heterogeneity, proprietary information

Parametric consistency vs. data model sharing



New Integration Infrastructure

Local solvers share causal mapping for externally accessible interface parameters



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:

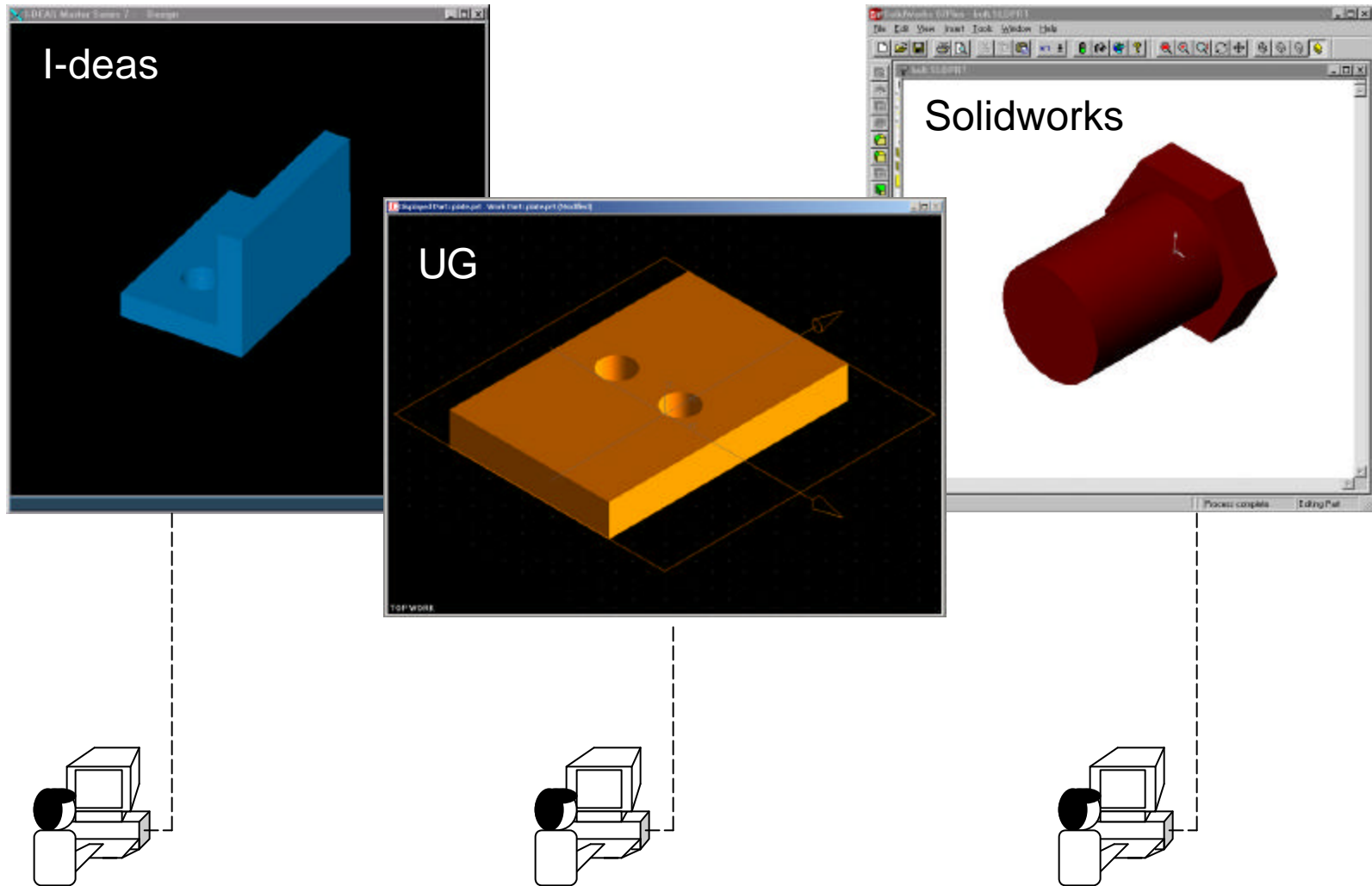
Each company has an official CAD system

All suppliers must use the official CAD system

Suppliers must provide native part geometry to automotive company

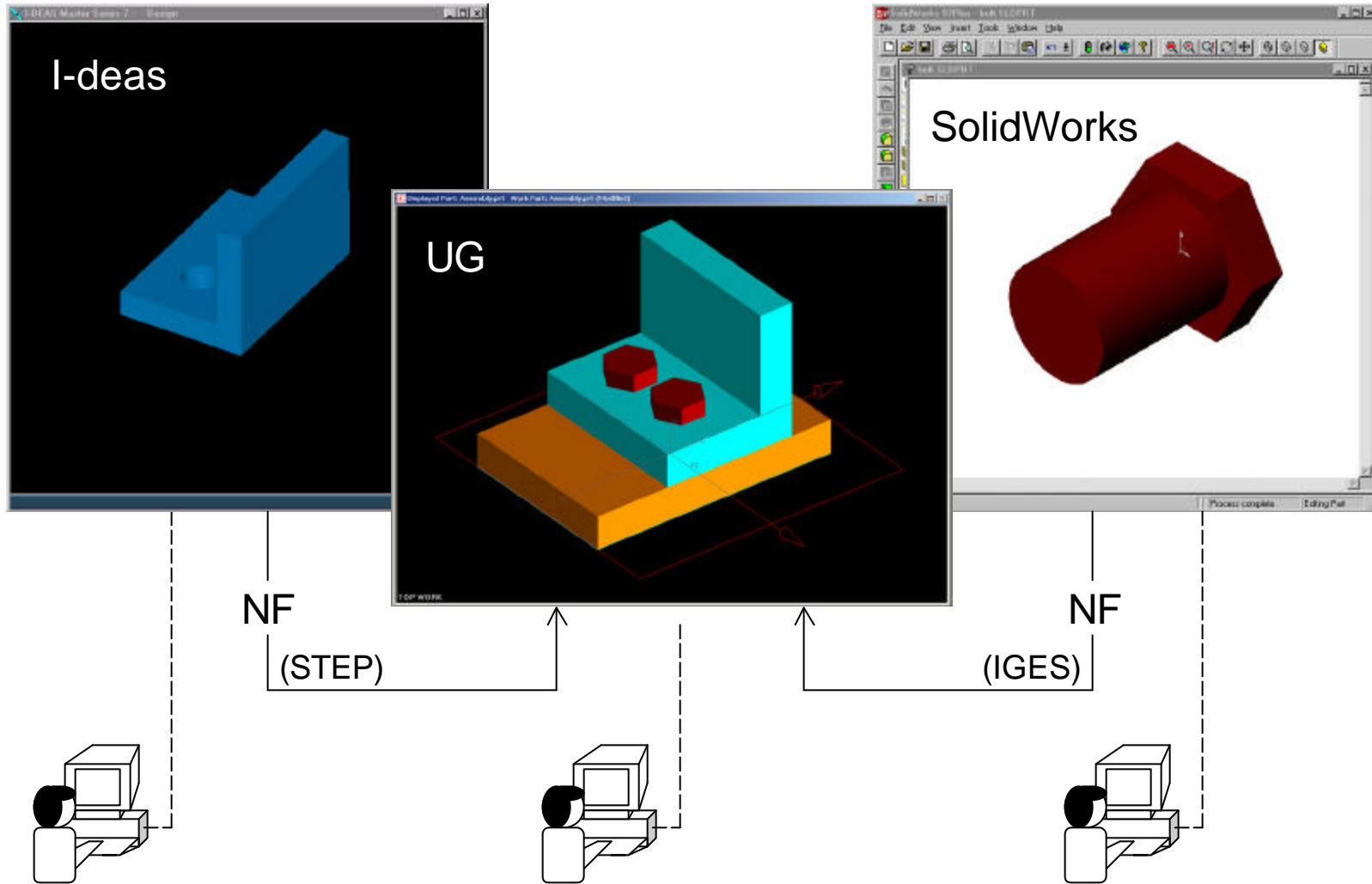
Vehicle Platform Application

Parametrically editable assemblies



Vehicle Platform Application

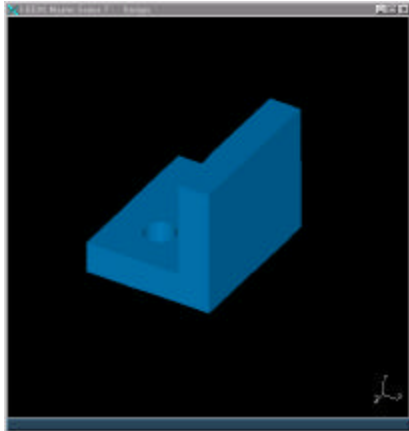
Parametrically editable assemblies



Vehicle Platform Application

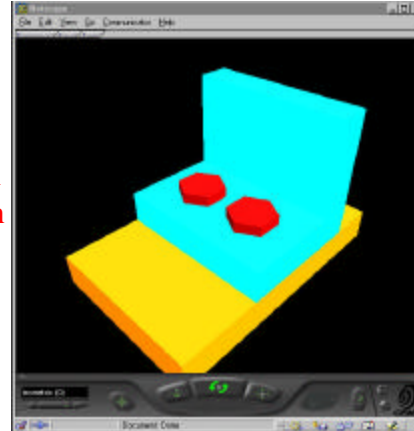
Parametrically editable assemblies

I-deas



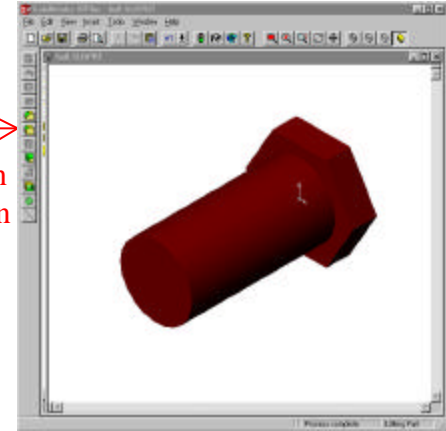
NF

UG



NF

SolidWorks



NF

Change in dimension

Change in dimension

Change in dimension

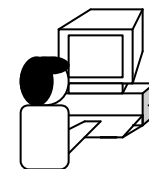
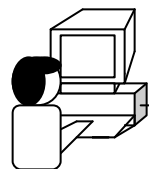
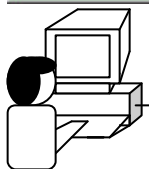
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Bracket_Supplier.mdl		
Bracket		
IDEAS		
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Analysis_Running	false	
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bracket_hole_diameter	0.75	in
bracket_hole_spacing	1.5	in
Neutral_File_Export		
Parametric_Inputs		
File_Relationships		
Simple_Demo		

Name	Value	Units
Assembly_Demo		
Assembly_Designer.mdl		
Bolted_Joint		
Unigraphics		
Parametric_Inputs		
plate_length	0.75	in
plate_thickness	0.5	in
plate_hole_diameter	0.75	in
Assembly_Relationships		
Bracket_Relationships		
Bolt_Relationships		
Cost		
Excel		
assembly_cost	0.61	\$
Simple_Demo		

Name	Value	Units
Assembly_Demo		
Bolt_Supplier.mdl		
Bolt		
SolidWorks		
Run_Analysis	true	
Analysis_Running	false	
bolt_diameter	0.75	in
bolt_length	1.0	in
Mass	0.03	kg
Bolt_VRMIL_export		
SW_IGES_export		
Parametric_Inputs		
File_Relationships		
LCA_Demo		
Simple_Demo		

DOMe Relations

DOMe Relations



Application

Manufacturing object module: MOM

