

Modeling Product Development Cost and Lead Time

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Outline

- Importance of Development Modeling
- Previous Work in Development Modeling
- Summary of Methodology
- Example
 - Description
 - Results
- Case Study
- Conclusions

Importance of Development Modeling

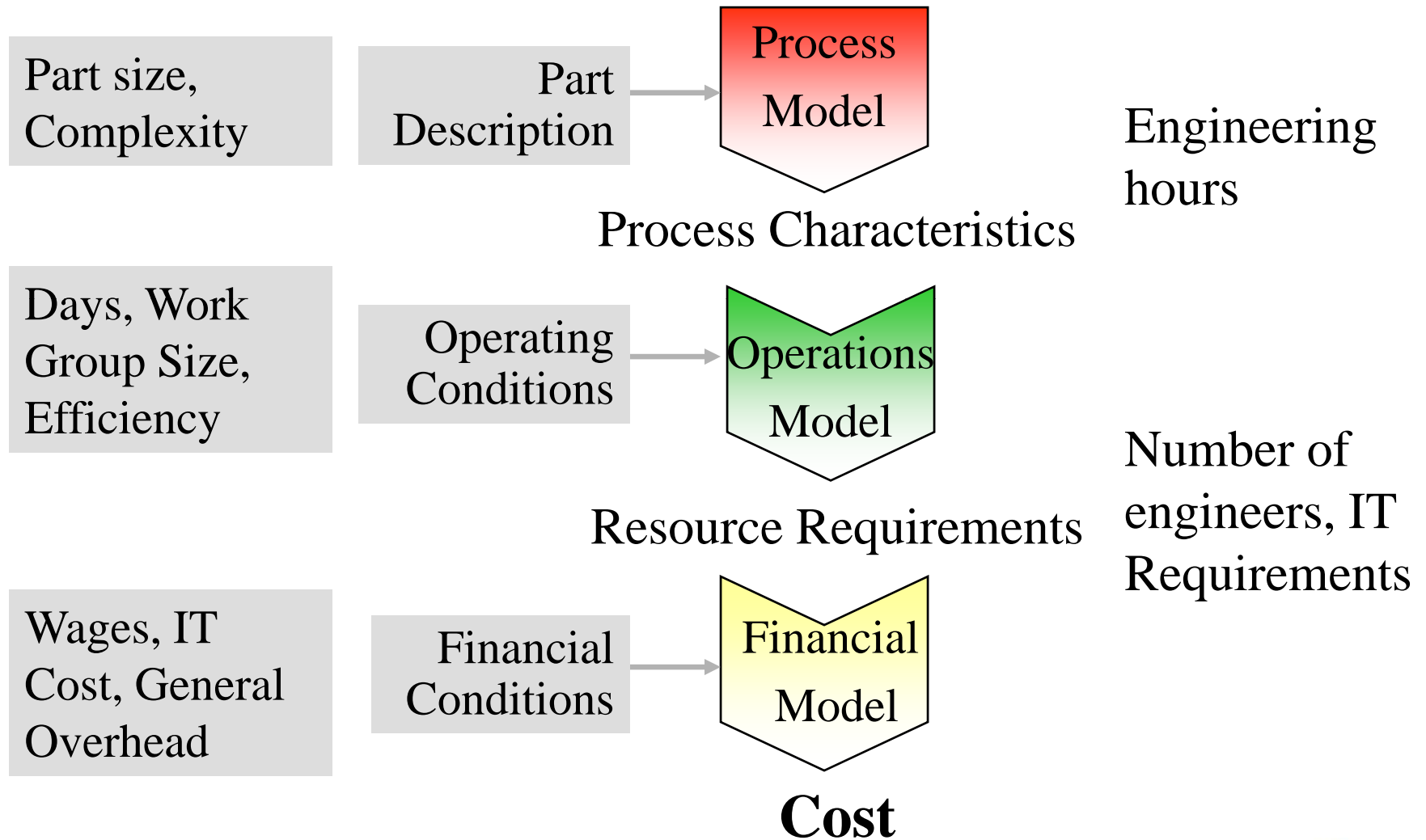
- More new products required and often with shorter cycle times
 - USN asked to do more; ship lifetime assumptions questioned (O'Rourke, 2004)
 - Requires better use of resources
- Development represents a large irrevocable investment
 - Often exceeding millions of person-hours and dollars
- Models allow the effects of design decisions to be analyzed
 - Can be done early stage, analytically, and explicitly

O'Rourke, R., *Navy Ship Procurement Rate and the Planned Size of the Navy: Background and Issues for Congress*, C.R. Service, Editor. 2004, The Library of Congress

Work in Development Modeling

- Two key metrics in development – lead time and engineering effort
- Most work focused on lead time and its effects – mostly very high level
 - Project Characteristics – Smith and Morrow (1999); Roemer et al. (2000); Griffin (1997)
 - Commercial and Technological Benefits – Hall and Jackson (1992); Datar et al. (1997)
- Lead time connected to engineering effort
 - Relationship between Engineering Effort and Lead Time – Clark et al. (1987) & Adler et al. (1995)
- Very little work relating engineering effort to component and process characteristics or cost
 - Component Characteristics – Roy et al. (2001)
 - Cost – Bashir and Thomson (2001)

PBCM of Development



Model of Automotive Product Development

- Interviewed several dozen engineers and managers at various stages of development to determine cost drivers



- Collected data about computer software and hardware, and physical prototypes
- Used linear regression analysis to relate product characteristics to engineering effort
- Utilized model analogous to production – similar to Adler et al. (1995)

$$C_{Total} = C_{Labor} + C_{Equipment} + C_{Software} + C_{Overhead}$$

$$C_{Labor} = wage \times \frac{RDT_x}{EngProd}$$

Formability Example

- Data Collection – 7 Engineers; 28 Parts

Survey

- Formability Engineer Experience (years)
- Part Complexity (roof -1 vs. floorpan -5; number of features)
- Part Size (length, width, depth)
- Surface Part (yes/no)
- Total Computer Time Doing Formability Analysis (hrs.)
- Number of Analyses Done
- Amount of CPU Time per Analysis
- Calendar Time Required for Formability Analysis (weeks)

Formability Example

-Correlations Between Variables-

	Formability Engineering Time	Part Complexity	Size of Part	Years of Experience	Surface Part (1-yes)
Formability Engineering Time		0.764	0.821	-0.118	0.390
Part Complexity			0.611	0.147	0.237
Size of Part				-0.176	0.360
Years of Experience					-0.151
Surface Part (1-yes)					

- As expected, complexity, size, and surface are positively correlated with engineering effort

Formability Example

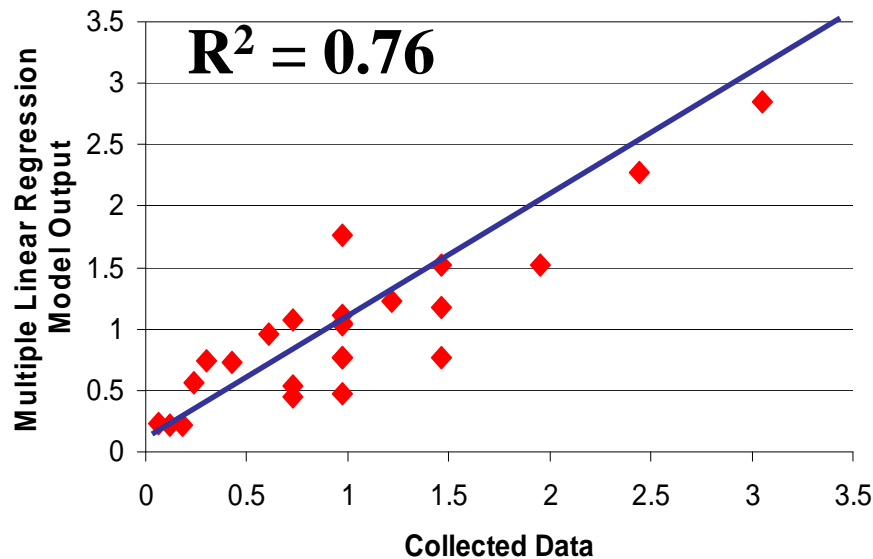
-Linear Regression Models-

Model	Constant	Size (dm ³)	Part Complexity	Surface Part (1=yes)	R ²	F-Stat
1	-0.030 (0.203)	0.001 (0.000)	0.233 (0.072)	0.190 (0.207)	0.76	25.4
2	-0.022 (0.202)	0.001 (0.000)	0.235 (0.072)	-- --	0.76	37.9
3	-0.321 (0.257)		0.428 (0.077)	-- --	0.56	30.8
4	0.568 (0.107)	0.002 (0.000)	-- --	-- --	0.66	45.3

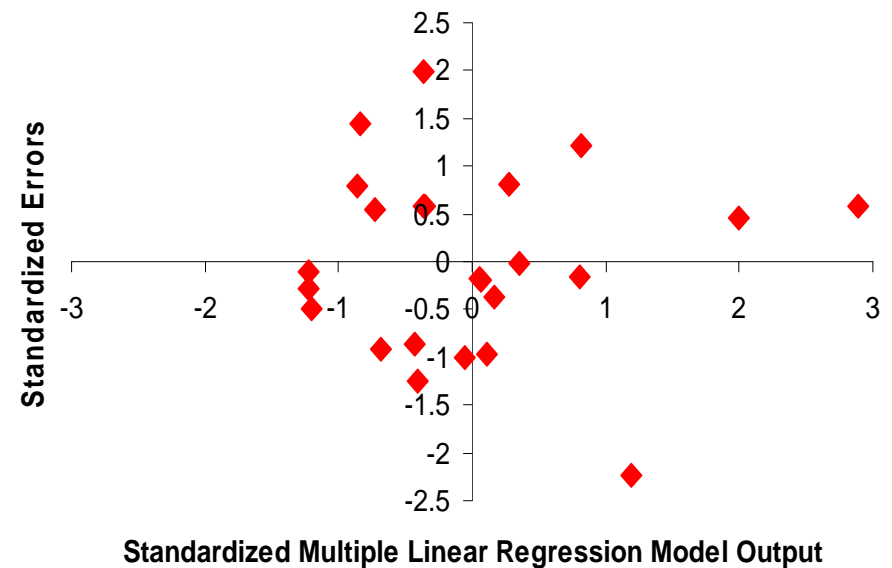
- Higher R² along with readily available inputs led to the use of model 2
- Computer hardware, software, overhead, and time spent doing other work used to estimate engineering effort and cycle time

Formability Engineering

	Coefficient	Beta	T-Stat	Sig.
Intercept	-0.022		-0.108	0.915
Part Size	0.001	0.565	4.402	0.000
Part Complexity	0.235	0.419	3.261	0.004



Good Fit

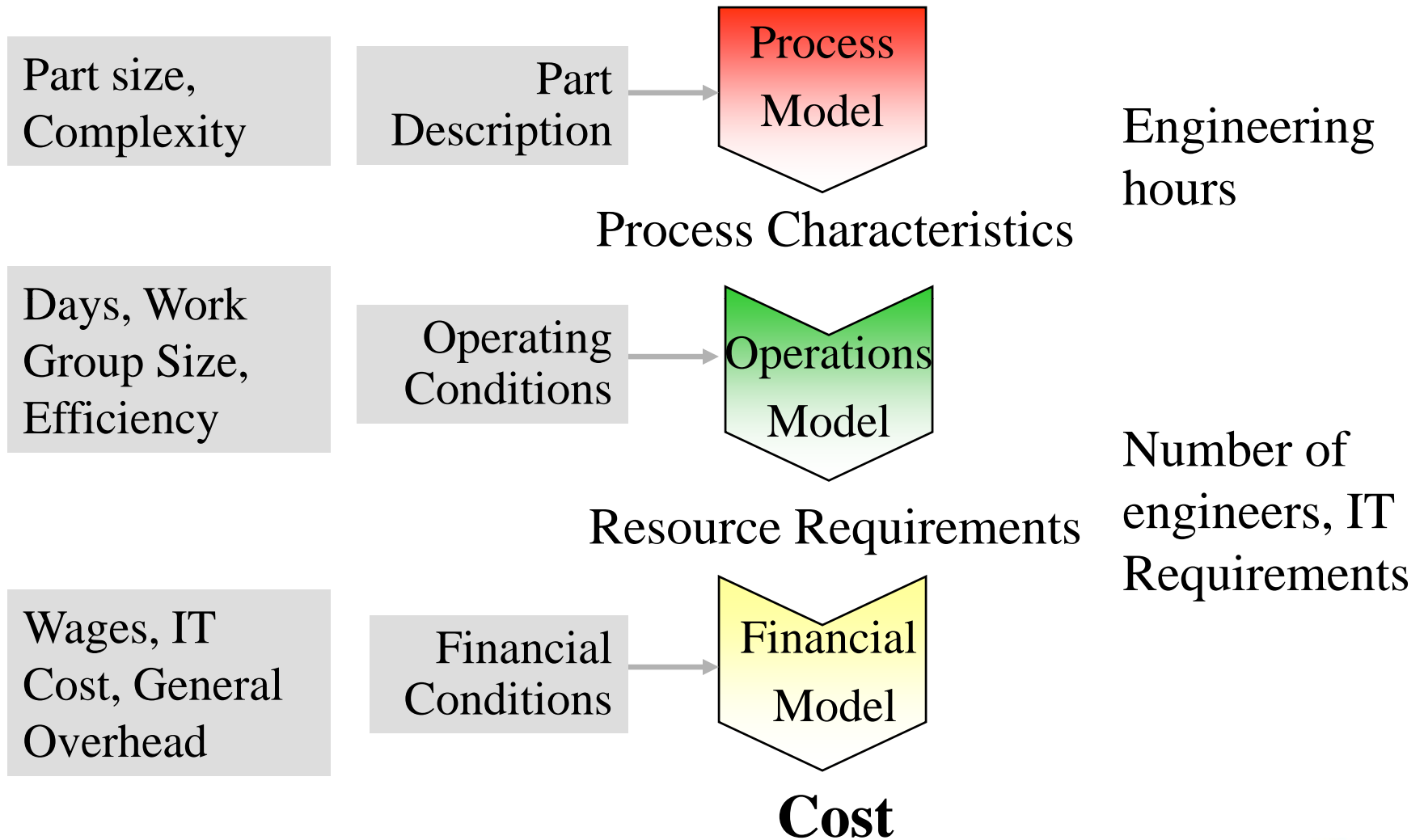


No Bias

Development Model Breakdown

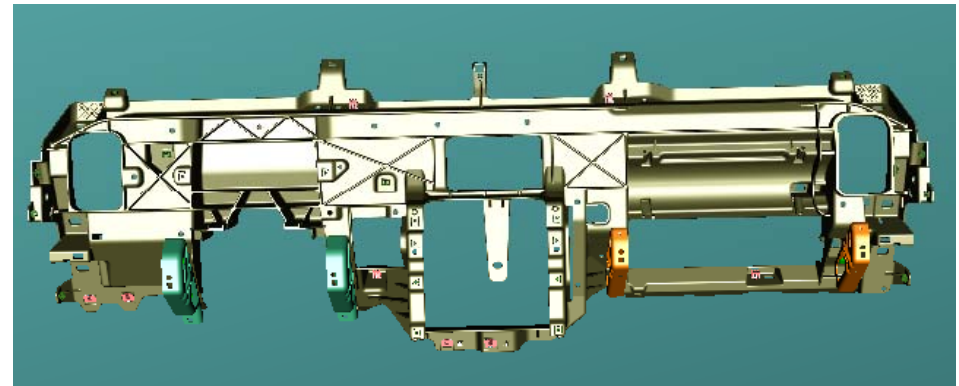
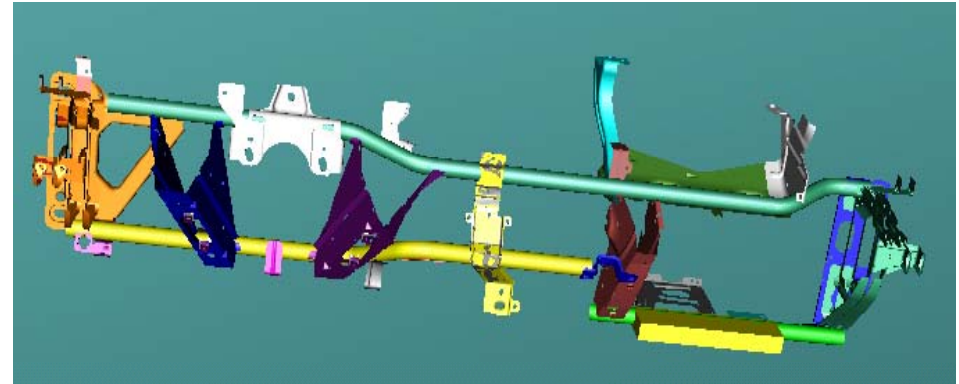
	Intercept	Size	Complexity	Concurrency	# of Parts	R ²
Design	X	X		X		0.47
Design – Scale Change	X	X				0.82
Formability	X	X	X			0.76
Stamping Fab. Engineering	X	X	X			0.96
Assembly Eng.			X		X	0.88

PBCM of Development

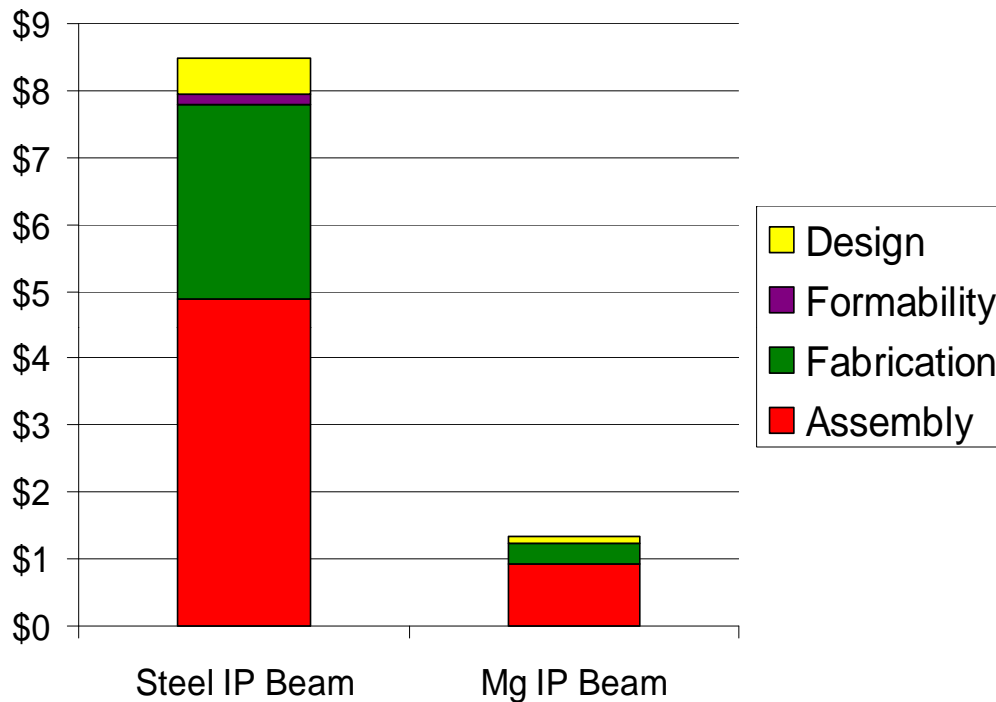


Instrument Panel Beam Case

- Steel IP Beam
 - Tubular steel structure
 - Over two dozen attachments
- Magnesium IP Beam
 - Die cast structure
 - Two pairs of brackets attached



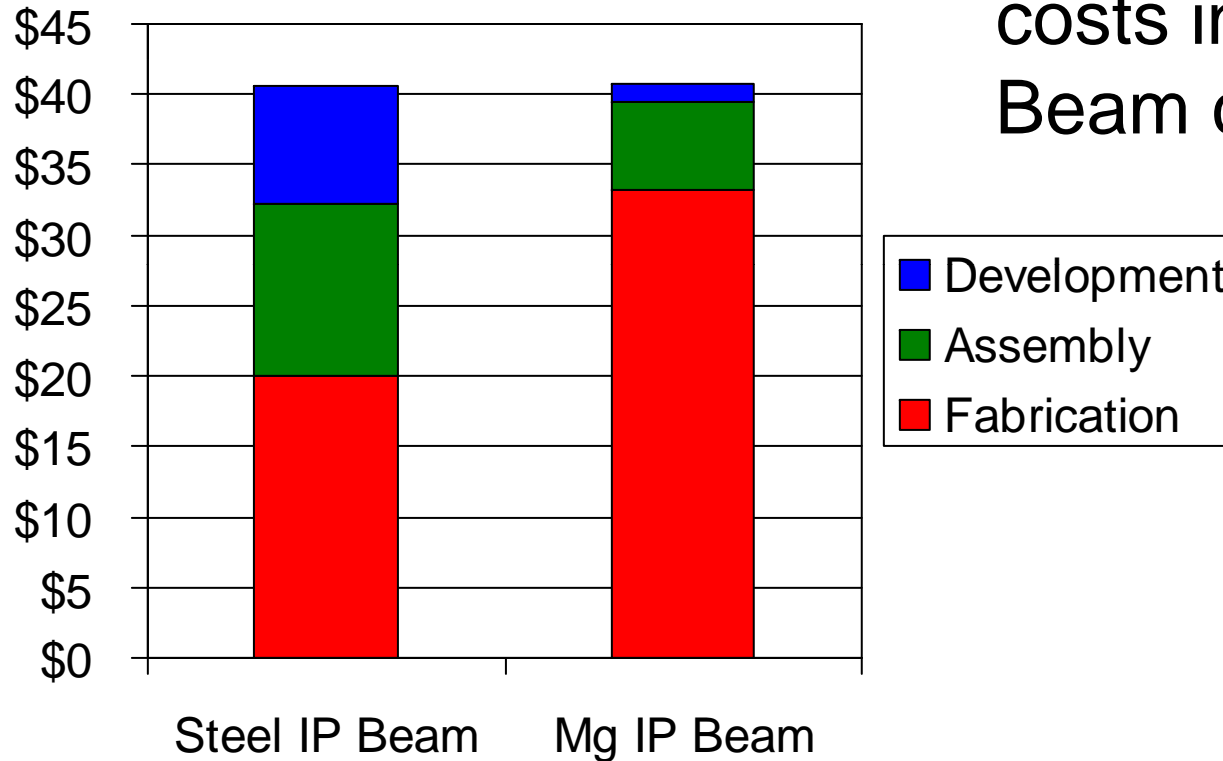
IP Beam Development Costs



- Steel beam 6x more costly
- Engineering of assembly process dominates
- Mg beam has major fabrication and assembly engineering savings

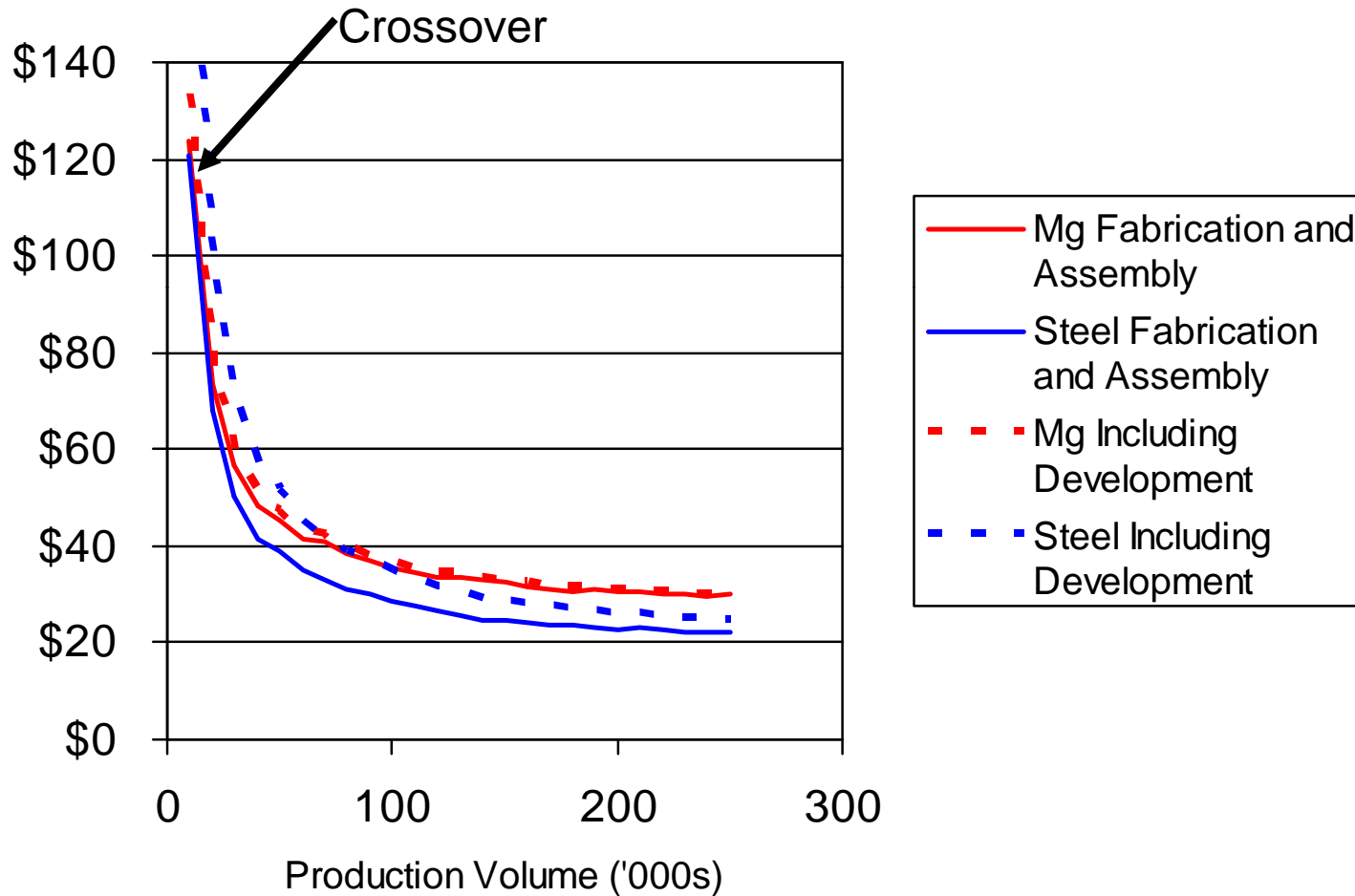
IP Beam Total Cost

- Reduced development costs increase Mg Beam competitiveness

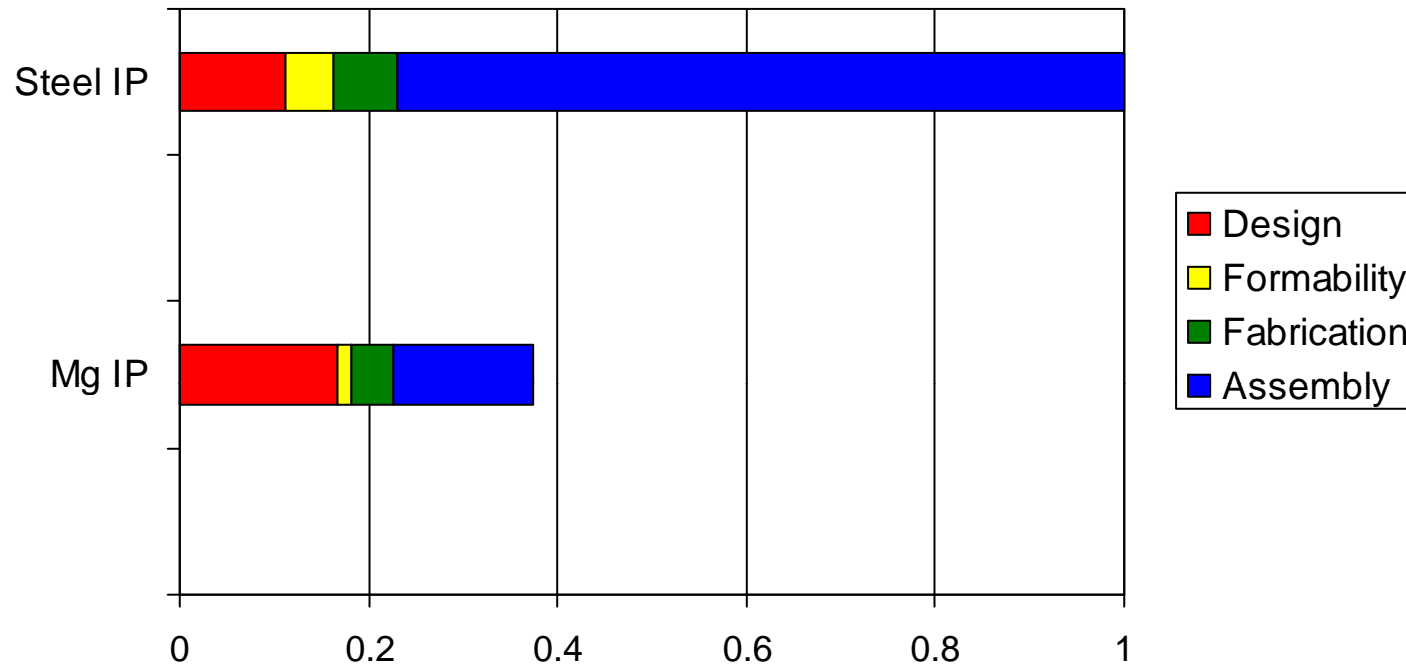


IP Beam Comparison

With Development Costs

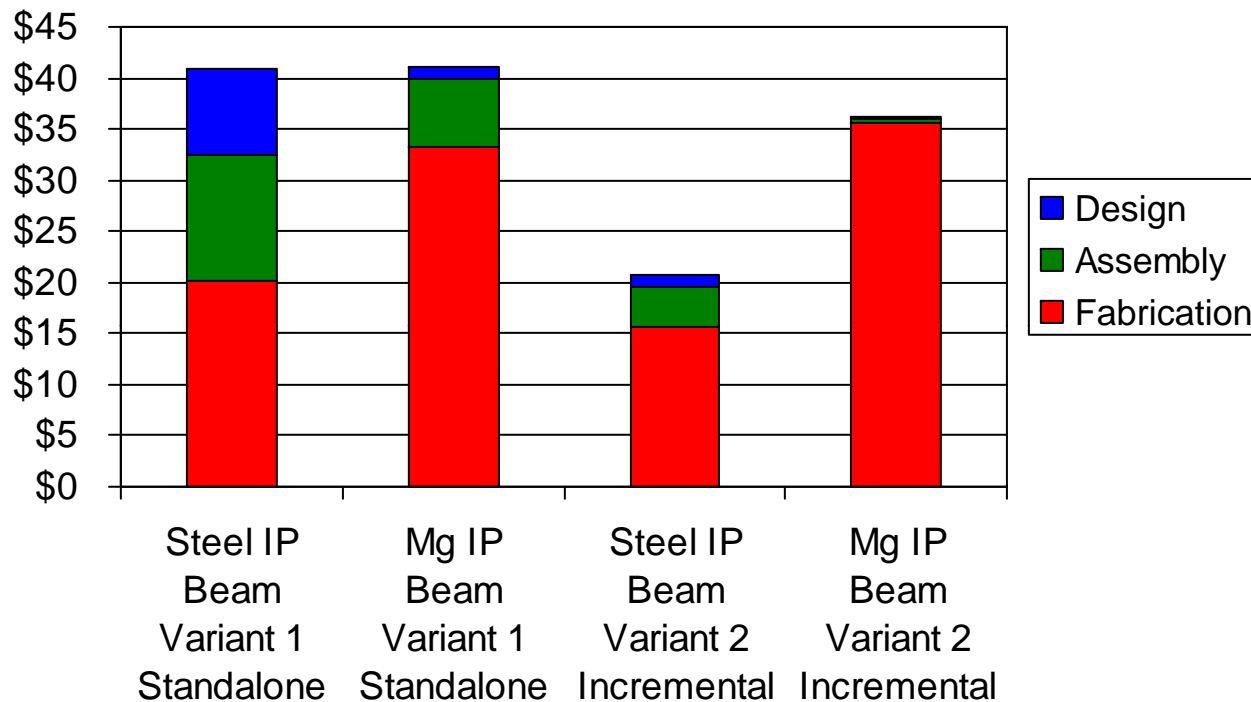


Development Lead Time



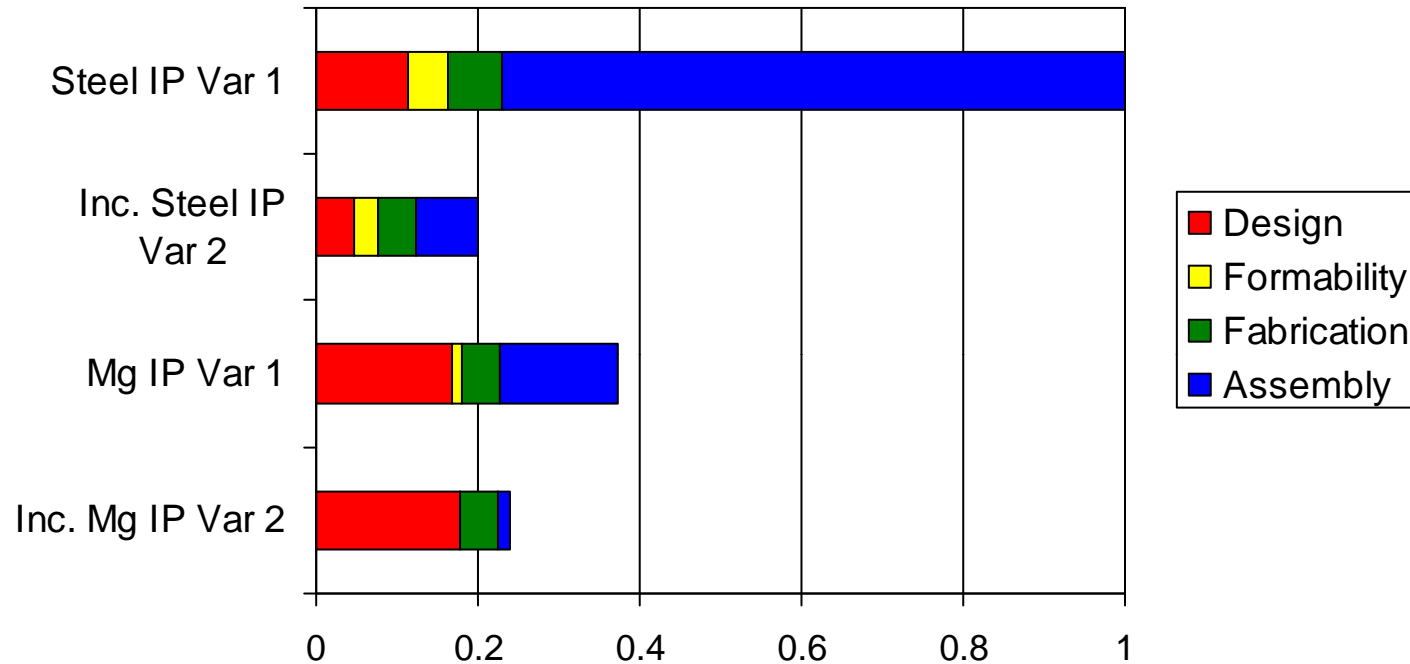
- Combination of design time and resources can be used to determine lead time
 - Key Variables: stage overlap, personnel resources, and work allocation
 - Important development metric
 - Can be related to cost and used for selection

Design Cost of Variants



- Design costs account for a range of total costs (20% - Steel; 6% - Mg)
- However, they make up a more significant share of total cost savings (36% - Steel; 16% - Mg)
- Should be taken into account when assessing the benefits of product families

Design of Variants



- The lead time required to develop variants can be considerably less than that of the original product
 - Could be viewed as an investment in some cases

Conclusions

- Product and project characteristics can be correlated to development effort and lead time
 - Effort can be used to project development cost
- The inclusion of the costs of development can alter the economically preferred technology choice
 - Provides basis for economic benefits of part consolidation
- Development cost savings as a result of part sharing account for a larger portion of total savings than expected
- The vast majority of development project cost (over 85%) is related to labor