4 Steps to Managing Complex Development Programs

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Construct a roadmap approach for successful completion of a complex project.

In chemical companies, new and better products and processes will ensure both company survival and increasing shareholder wealth. New products improve life for customers and bring the rewards of competitive advantage, while process innovations bring incremental and breakthrough systems for production. In a capital-intensive industry, these improvements are critical to survival. Often, development efforts for new products and the processes to make them go hand in hand.

Unfortunately, many R&D managers treat all development efforts pretty much the same. Consciously or unconsciously, they fail to allot the extra attention deserved by more vital (as measured by business contributions) new product and process development (NPPD) programs. Their organizations win recognition for great technology, but produce little business success.

A four-step method is proposed that addresses the business issues that go with complex projects.* It emphasizes the significance of the early identification of complex projects, which hinges on several key factors. The most important ones relate to the products that come from the technology, proprietary considerations, and timing of the product lifecycle. A daunting obstacle to new technology can be the current organization and its embedded production and sales structure. New technology can, even should, upset the current ways of doing business.

For those programs identified as complex, management needs a roadmap for proceeding. This is developed around issues, windows for addressing the issues, and models of program economics to measure where you are in your journey.

STEP 1. Determine if the project is simple or complex.

NPPD projects vary in terms of issues that have to be addressed — some are relatively simple with a few, straightforward issues, while others are more complex with many difficult issues. Unfortunately, complex projects managed as if they were a series of simple projects may meet individual goals, but the overall program of which they are a part fails. There are several tests that distinguish between simple and complex projects (Table 1). To be rated complex, an initiative does not have to be complex in all of the categories — just one will do. Also, a new product or process initiative isn't simple or complex by virtue of technology, only, or the size of its budget or staff. Often, the complexity arises from business issues that may or may not be the domain of R&D managers. Tests for complexity can be categorized into the following:

Control — One test for complexity is to determine the level of control required over the improvement effort. In some complex cases, a program can be devel-

*This article builds on an earlier *CEP* article that introduced tools for managing development *(1)*.

Table 1. Tests to distinguish between complex and simple projects.

Issues	Simple	Complex
How do we control it?	Standalone "project" control suffices	Requires multiple-project control
Is it new to us?	Improves existing product or process	Develops new product or process
Is it new to everyone?	Has low technical risk	Has high technical risk
Is it vital to our future?	Has low strategic contribution	Has high strategic contribution
Are others involved?	Confined to single function or company	Supply/value chain involved

oped in which the effort is divided into several related projects *(2)*. The reasons for doing this can include the size of the development team, the length of the project and the budget. If splitting is justified, the related projects need a separate method of control.

Traditional complexity factors — The second and third items in Table 1 test traditional views of complexity — “Is it new to us?” and “ Is it new to everyone?” For the former, many companies already use this test to categorize R&D projects. Those technologies that are already deployed in the company presumably offer less risk. New technologies are riskier, particularly when it comes to implementation. The newness may be due to product technology, the way the product is made, or the markets that have to be entered.

For the third item in Table 1, the technology itself is the risk. This “bleeding edge” factor is the one most R&D managers are concerned about. However, over-focusing on technology may cause other business risks to be neglected or ignored altogether. Also, an R&D manager errs if he or she restrains from implementation to achieve zero technology risk. It sometimes takes a brave R&D manager to let new technology out of the box so other departments can get on with commercialization.

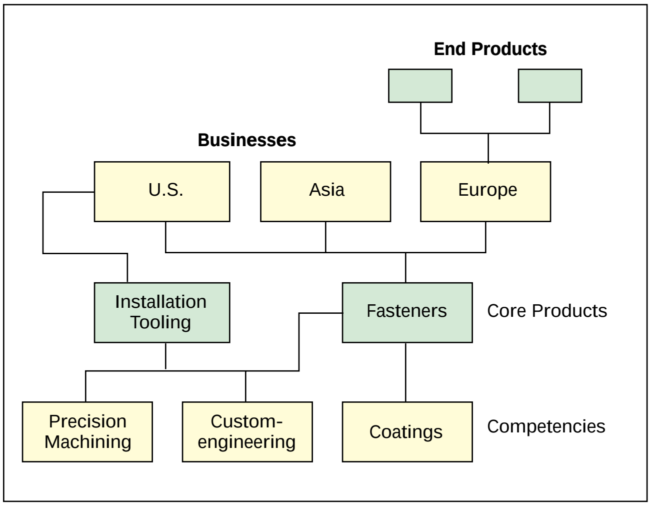

Figure 1. The relationships among core competencies, products and businesses for a hypothetical aerospace fasteners manufacturer.

Strategic projects — This test addresses strategies for competing. Certainly, a goal of development is to turn out technology that creates growth and increases shareholder value. But how complete are processes for evaluating this potential? Executives and R&D managers can distinguish strategy-supporting NPPD projects by evaluating core competencies and product lifecycle.

Core competencies — Some NPPD programs create new core competencies that typically have three characteristics: they must provide access to multiple markets; contribute to perceived customer benefits; and be difficult to duplicate *(3)*. Sometimes, the potential of an NPPD project to add to competencies isn’t anticipated. The outcome can be widespread disruption in ways of doing business. Figure 1, for example, illustrates the pitfall where management’s focus on the end products and businesses results in the neglect of its core competencies and products. The competencies illustrated are for a hypothetical maker of aerospace fasteners. They include close-tolerance manufacturing, the ability to design specialized fasteners, and knowledge of coatings (a key to installation and durability). There are two product categories: the fasteners themselves and the tools to install them during aircraft construction. This company organized its businesses by region. The business units sell many product variations that are tailored to customer applications in these markets.

Core competencies and core products are fundamental to the ability to compete. But, they are often latent, shown as the roots of a product tree. Business units marketing the existing portfolio of end products are quite visible — the leaves on the product tree. They constitute the corporate organization, its manufacturing facilities, its distribution chain, the sales force and a myriad of support processes. Top management closely measures the performance of these business units. However, hardly anyone may look after the core competencies.

Complexity comes when new competencies severely disrupt existing businesses and the end products they market. NPPD technologies that fit this category fundamentally alter the company business model. If an NPPD effort will bring on this disruption, it certainly qualifies as complex. Unfortunately, R&D managers sometimes shrink from meddling with the existing power structure.

Product lifecycle — Figure 2 depicts the product lifecycle, a widely used model of market behavior *(4)*. It shows four lifecycle stages: inception, growth, maturity and decline. Along the bottom is a graph of revenue over the four stages.

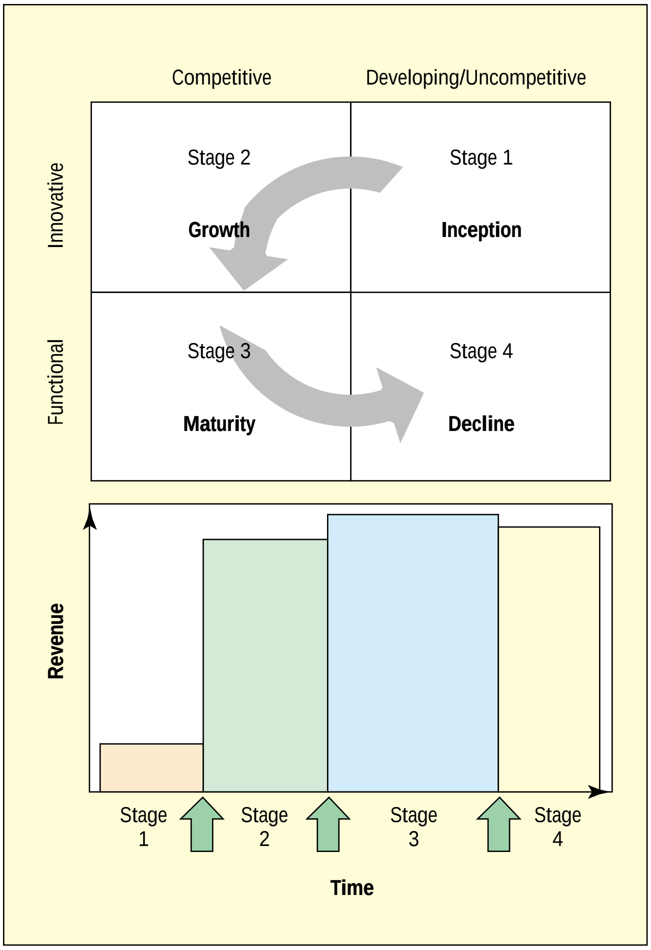

Figure 2. The product lifecycle consists of four stages — inception, growth, maturity and decline.

During inception, Stage 1, there are many product changes, and supply chains for component sourcing and product distribution are just beginning to take shape. Recent research indicates that vertical integration is the best model in Stage 1 *(5)*. With vertical integration, the company maintains capabilities internally, in order to control quality. Companies need to control product development and production as the market takes shape.

Production-process integration supports this need. A chemical company might need to develop new chemicals or processes to support the new product. It also might enter into agreements to maintain exclusivity over this technology. On the other hand, it is also possible that the product is based on existing commodity chemicals. If so, there may be little interest in the product from the marketing and sales departments, because volumes are small.

In the Stage 2 growth period, there can be multiple producers. High growth provides ample sales for everyone — profit margins soar. Innovation in design is also rapid, as new customer applications and product features emerge. Competitors continue to be integrated since product standards are still evolving.

A chemical company providing raw material for the Stage 2 product will work to improve product performance and lower the cost. If the product uses commodity chemicals, the market will be increasingly attractive to the marketing and sales department as volumes expand. In this phase, the chemical company will create special supply-chain accommodations to serve the growing market if they are needed.

In Stage 3, maturity, growth peaks and competition stiffens. Competitors race each other for market share. The product design itself has evolved so that it satisfies most customer needs *(5)*. There is only marginal gain from technology innovations that enhance product design. At this point, standards also emerge for components. In this environment, vertical integration no longer makes sense, as specialist suppliers produce each major component. The focus of competition shifts to process improvement and the supply chain's ability to cater to customer needs.

Also in the maturity stage, profits flow to the supply-chain members holding onto proprietary technology *(5)*. For example, as the personal-computer industry matures, there is little profit in the final assembly and sales. A chemical company that has retained control of its technology can enjoy continued profits even as growth slows.

Conventional wisdom calls for companies to dump R&D and investment-intensive operations to improve return on investment (ROI) for Wall Street. This may be shortsighted. Winners are those who retain proprietary technology; losers are those who outsourced technology earlier in the lifecycle *(5)*.

Table 2 is a guide for evaluating the strategic potential of an NPPD project. One must first determine the current lifecycle stage for products related to the technology project. Another question is whether the process or product technology will be proprietary. If so, the NPPD project is more

Table 2. Criteria for strategic contribution.

Stage	Exclusivity	Strategic Contribution Yes	Strategic Contribution No	Notes
Inception	Proprietary	?		Depends on volume/profit forecast
	Commodity		?	Depends on volume/profit forecast
Growth	Proprietary	X		High sales and margins likely
	Commodity	X		High sales and modest margins likely
Maturity	Proprietary	X		Will enjoy profits in mature market
	Commodity		X	Very competitive; cost-cutting pressure
Decline	Proprietary		X	Declining sales/profits
	Commodity		X	Declining sales/profits

likely to be strategic. In some cases, such as a product in Stage 1, the answer to the question, "Is this project strategic?" will depend on forecasts of market potential.

Supply chains — Few of the larger NPPD programs are confined to a single company. Throughout the lifecycle, shared technical expertise, capital participation, supply-chain agreements, and negotiated financial arrangements accompany technology development. Such agreements can threaten company exclusivity over product or process technology. However, giving up that exclusivity may be the price of participation.

In Figure 2, products compete principally on product features in Stages 1 and 2. At the end of Stage 2 and into Stage 3, the supply chain becomes prominent in determining the winners and losers. As described above, the supply chain may evolve away from integrated firms to "specialists." For the technology manager, this calls for bringing in supply, distribution and sales partners. For example, process improvements that are desired by a chemical company may be implemented at its supplier, making cooperation essential. Likewise, customers of chemical companies will demand cost reductions in Stage 3, increasing the importance of "process" relative to "product" projects. Another trap is pursuing product-enhancing projects when the product is in Stage 3. These projects may hold little value to customers.

All these factors raise issues of financing, phase-in, product qualification, sharing of profits and coordination, making the NPPD effort complex, rather than simple.

Name of the issue (Identifier, descriptive phrase)
Category (select one): Technology – relates to feasibility Marketing – relates to commercial development of the technology Financial – relates to profitability, capital investment, partner terms Organization – relates to people requirements, structure and timing Program – overarching issues that affect the program
Description (questions to be answered): *Defines the issues in the form of questions that have to be answered*
Status (current direction): *What decisions have been made? What is the result if we continue as currently planned? What risks do we face if we don't decide?*
Decision (what our direction should be): *Our decision. What we plan to do. This can be modified with changing circumstances.*
Technology interface (technology link): *How the issue relates to development of the product or process technology.*
Manufacturing interface (manufacturing link): *How the issue relates to production facilities, investments and the supply chain.*
Products (that the issue applies to): *Products to which the issue applies.*

■ Figure 3. Shown is an example of an issue template. An issue expresses an uncertainty about the execution of the program and needs to be discussed prior to the programs, moving forward.

STEP 2. Define the issues.

Once a project or a group of projects qualifies as complex, the manager must define that complexity in the form of issues. After Step 1, the program manager will have acquired insights into the causes of complexity in the project. They are likely to fall into one or more of the categories in Table 1.

Issue definitions take the form of questions to be answered in order to proceed. Each issue expresses an uncertainty about the execution of the program. Issues raised now will call for future decisions along a program timetable. Issue descriptions are accompanied by the current direction, the timing of the decision and other dependent issues, and the data needed to make a decision.

Figure 3 is a template for an issue. Issues are logically linked to different categories, such as finance (*e.g.*, cash flow, sales model, customer financing and transition from R&D to business), organization (*e.g.*, leadership, legal entities and incorporation into existing businesses), marketing and sales (*e.g.*, business model, marketing strategies and sales force capabilities), technology (*e.g.*, product variations, performance demonstration, and prototypes and testing) and the supply chain (*e.g.*, strategy for make/buy, contracting with partners and aggregate production planning). Some issues require immediate decisions, while others can wait. The path from "here to there" is not unlike a minefield with hazards lurking all along the way.

There are many techniques for uncovering issues. Sources include workshops and questionnaires to survey participants, consultants, customers and supply-chain partners. Issues may be modified, added or deleted at any time. When a decision is made or changed, it should be documented just like updates to schedules. Development of issues includes assignment to the party responsible for the issue's resolution.

STEP 3. Set your "windows."

The label "windows" refers to time periods in which certain program activities must be accomplished. Windows are the skeleton for the program timetable and schedules for related projects. Windows don't supplant traditional schedules used to plan and track individual projects. Instead, they determine the timing of those projects by defining constraints for the overall program. For further reading, Rita McGrath and Ian MacMillan de-

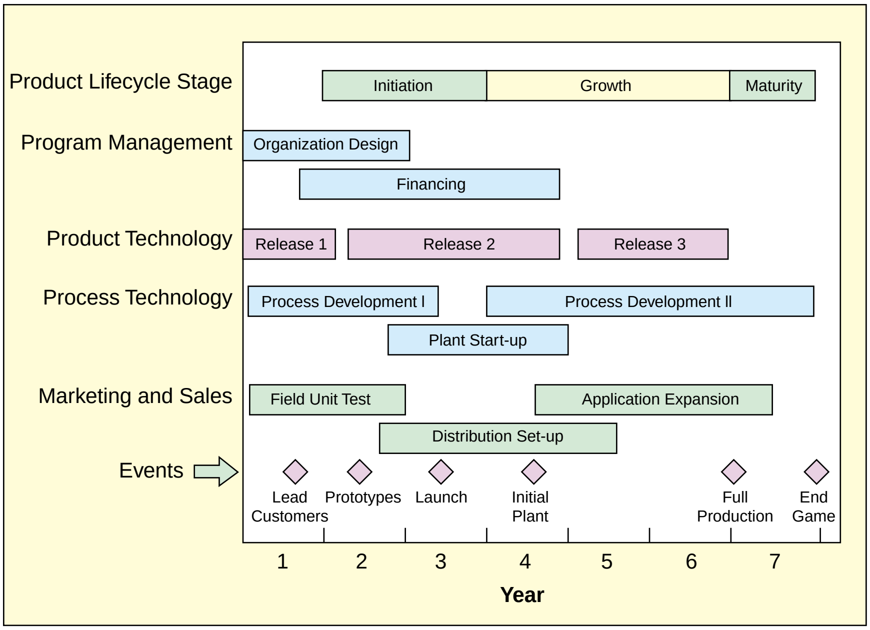

Figure 4. Shown is an example of "windows" for an R&D program. The windows are designed to encompass the efforts needed from a variety of disciplines.

scribe a similar technique called "discovery-driven planning" that establishes milestones and expectations for new-product introductions *(6)*.

Windows include technical performance goals, important events and the dates when each event should be completed. The timeframe should be appropriate to the program. For some major programs, it could be 3–8 years, including not only development, but also post-launch deadlines. This can be problematic in some companies, since responsibility for a technology changes hands after launch from R&D to a business unit.

Windows should incorporate strategies for lifecycle management of the product. One approach is to define the "end game" for a product (product maturity) and work back to "pathway" scenarios (initiation and growth stages). An important component is the expected product-delivery requirements during the product's lifecycle. This is a function of cost, production capacity, market size and market penetration.

Figure 4 illustrates NPPD program development windows. The windows are designed to encompass the efforts needed on a broad front, enlisting the efforts of a variety of disciplines. Each window contains individual projects that respond to issues developed in Step 2. In this example, there are four windows called program management, product technology, process technology, and marketing and sales. Each issue should be addressed in one of the windows. Also shown in Figure 4 are the product lifecycle stages and major milestones, at the top and bottom, respectively.

STEP 4. Build a financial model.

For the NPPD program manager, the financial model is an important element of the decision-support "control panel." The model has two parts: a top-down component that models demand economics, and a bottom-up component that models supply economics.

The top-down component translates market pricing into allowable costs for the product. It is usually expressed in unit costs that fit the product (*e.g.*, per unit, per kg). The top-down model starts with the market price for existing technology and deducts for the costs of supply-chain components, sales and marketing, and general and administrative costs. This yields the upper limit for the "bottom-up" cost, setting how much the program can "afford" to pay for the technology under development.

The bottom-up model tracks the cost of processes needed to make the product. In the case of an entirely new product, it could mean building a production system from the ground up. It incorporates the bill of materials (BOM), and the value-adding steps performed by the supply chain for the product. In some programs, existing facilities will produce the new product. The model should capture needed changes to existing facilities required to produce the product. Then, the model should show how investments would be recovered in product prices or cost reductions.

Figure 5 illustrates the most ambitious case — the modeling of a new product that requires new manufacturing processes. To allow a dialog on costs, the processes in the model, including materials, manufacturing and distribution, should be defined. Figure 5 shows segments in the process. Each segment has multiple operations that the model documents in detail. Note that the model includes processes performed by major supply-chain partners that are treated the same as internal steps in the process. This inclusion is especially appropriate when these partners will invest in the new business. Inclusion will also make transfer price negotiation easier.

Table 3 displays segment-level costs in the process. An analysis shows that, at 100% yield, total BOM costs are \$4/unit. Internal process costs, including supply-chain partners, are \$10.36, for a total cost of \$14.36. This is calculated at 100% yield to separate the yield effect from process design. Internal costs should include capital recovery of investments in plant and equipment. These capital-recovery calculations convert capital to expense and incorporate assumptions about the cost of capital and investment life.

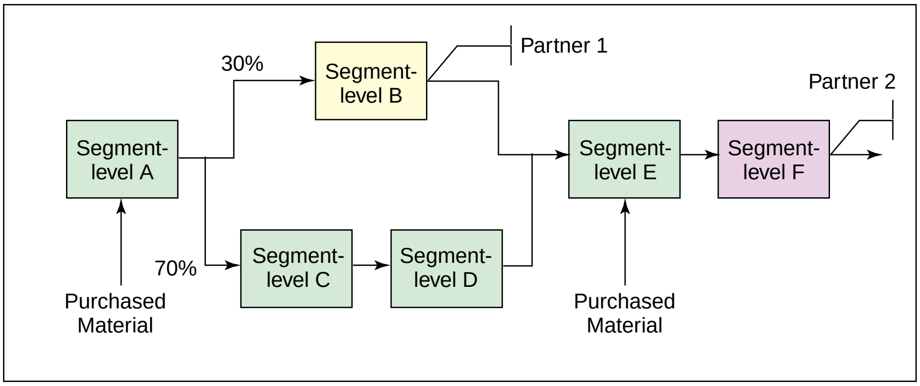

Figure 5. The bottom-up financial model, shown here, focuses on "activity-based costing" and is widely used to improve management decision-making.

Yield is tricky, because costs can vary widely depending on yield estimates. Often, managers or engineers mistakenly make yield assumptions for the entire process, which leads to faulty conclusions about costs and capacity needs. For example, in Table 3, yield adjustments show that capacities at Segment A must be doubled in Scenario B to compensate for yield losses downstream in the process. It is important to examine BOM cost to discover ways to work with supply chain partners to lower unit costs or design out expensive components.

This approach to modeling enables conducting a sensitivity analysis based on the yield as shown by Scenarios A and B. Yields in Scenario B are 5% less than they are for Scenario A for each segment. The model calculates cumulative yield, while taking into account the parallel pathways in the flowchart. Note that Scenario A produces a product cost after a yield adjustment of $22.68 per unit; Scenario B's cost is $27.28, a 20% increase.

The bottom-up model format is useful for making decisions required of a program manager. It is process-oriented, not account-oriented, and takes a form of "activity-based costing" that is widely used to improve management decision-making. The bottom-up approach also includes ROI and capital costs in the calculation — factors that are distorted by conventional accounting. CEP

Table 3. Example of segment-level costs.

Segment	Bill of Materials Cost	Process Cost (100%)	Yield Scenario A	Cumulative Yield A	Product Cost A (yielded)	Yield Scenario B	Cumulative Yield B	Product Cost B (yielded)
A	$3.00	$ 3.70	90%	59%	$11.30	85%	48%	$14.10
B		2.19	75%	54%	4.06	70%	45%	4.91
C		0.20	90%	62%	0.32	85%	49%	0.41
D		0.63	95%	68%	0.92	90%	57%	1.10
E	$1.00	2.35	80%	72%	4.65	75%	64%	5.25
F		1.29	90%	90%	1.43	85%	85%	1.52
Totals	$4.00	$10.36			$22.68			$27.28
								Increase: 20%

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