Scene I-1: STANDARD OPEN	Narrator Manufacturing Insights ... SME's videotape series for industrial management.
Scene I-2: U: 03-21-15	This program will show you how to produce "RAPID TOOLING, RAPID PARTS"
Scene I-4:CD: 09-15-26	You'll see how Rapid Prototyping processes, also called RP, get new products into production faster, and at less cost ...
Scene I-5: U: 02-01-38	.... for consortium members served by the Speed Scientific School of the University of Louisville, where Selective Laser

	Sintering produces wax patterns for investment castings ...
Scene I-6: U: 02-10-04	and tough nylon parts for rigorous application testing ...
Scene I-7: F: 00-04-27	... at the Ford Motor Company Alpha Research Center, where all major RP processes are being explored as part of an emerging vision of what engineering can become ...
Scene I-8:	... at Chrysler Corporation, where RP parts for a prototype intake manifold proved tough enough for full-throttle engine testing by the Advanced Engine Development Group ...

Scene I-9: G:02-27-28	... for customers of General Pattern Company, where the Cubital Solid Based Curing process is creating durable Liquid Injection molds that can produce fully functional plastic prototype parts...
Scene I-10: L: 11-09-41	...and for customers of Laserform, Incorporated, Michigan, where the latest Stereolithography modeling materials and build geometries are producing improved part patterns for secondary tooling and investment-cast parts ...
Scene I-11: CD: 09-15-26	...and where RP patterns made for Ford Motor were used to investment-cast, injection-mold tooling that produced fully testable

parts in a production material.

Scene I-12:

We'll also show you the Soligen process that generates ceramic casting shells for very fast turnarounds in producing investment-cast metal prototype or production parts.

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Scene I-13: L: 11-06-58

Rapid Prototyping systems have been available since the late 1980s, when 3D Systems of Valencia, California introduced the first Stereolithography machines.

Scene I-14:

Today, five of these systems continue to account for over 90 percent of commercial use in the U.S.

Scene I-15a:	All are programmed by a "STL" file -- created by converting initial data from a CAD solid model to two-dimensional cross sections, or "slices," that range in thickness from 3-thousandths to 20-thousandths of an inch.
Scene I-15b: U:03-31-09	On the modeling machines, the RP part is created cross-section by cross-section, transforming the CAD solid-model data to a three-dimensional object.
Scene I-16: Repeat CD: 09-15-26	This tie to the CAD data is a major advantage of Rapid Prototyping. From the first RP model ...

Scene I-17: CD: 09-15-26	to fully testable parts ...
Scene I-18: CD: 09-15-26	every prototype generation is a faithful reproduction of the CAD design.
Scene I-19: F:00-27-21	RP build processes and materials vary widely, this leads to differences in ...
Scene I-20: F: 00-28-27	maximum part size and build time ...

Scene I-21: L: 11-07-03	setup and post-processing requirements ...
Scene I-22: U: 02-12-00	and model toughness, accuracy and detail.
Scene I-23: F: 00-10-03	Each system offers its own unique mix of capabilities ... and may be best for a given set of prototyping objectives.
Scene I-24:	In brief, the five major RP systems create three-dimensional part models as follows:

Scene I-25: L: 11-05-22	With 3D Systems' machine, called "SLA" for "Stereolithography Apparatus," an ultraviolet laser traces and hardens cross sections of the part shape in successive layers of a liquid photopolymer resin.
Scene I-26: L: 11-15-39	This process generally produces the tightest dimensional accuracies.
Scene I-27: G: 01-19-09	With Cubital America's Rapid Prototyping machine, each successive cross section of the part shape is first electrostatically imprinted on a glass plate, much like an image is placed on the drum of a copy machine.

Scene I-28: G: 01-19-42	Next, the plate moves to a precise position over a layer of photopolymer resin, where...
Scene I-29: G: 01-20-05	strong ultraviolet light hardens and cures the image in the resin.
Scene I-30: G: 02-07-07	The Cubital system provides excellent throughput, based on a large work envelope and nesting hundreds of parts in a single batch.
Scene I-31: U: 03-32-09	The Selective Laser Sintering system developed by DTM Corporation, Austin, Texas, uses a fine powder instead of a liquid polymer as its build material. A powerful carbon-dioxide laser selectively sinters each layer of powder grains into

the cross section shape.

Scene I-32: U: 02-10-54	This system offers the widest range of modeling materials, including investment-casting wax, and tough polycarbonate and nylon.
Scene I-33: F: 00-16-18	The Fused Deposition Modeling machine developed by Stratasys, Incorporated, Minneapolis, builds up the part cross sections using a spool of thermoplastic filament fed through a heated extruding nozzle. Because no laser is needed for shaping successive layers and modeling materials are inert and non-toxic...

Scene I-34: F: 00-19-03	...the machine can be used in an office environment.
Scene I-35: F: 00-26-02	With the Laminated Object Manufacturing process, developed by Helisys Inc., Torrance, California, sheets of paper-like material are pulled into place over the work area ... and heat-sealed to a base or the preceding layer.
Scene I-36: F: 00-27-21	A laser then cuts the outline of the cross section, or "slice," of the part. At the same time, it cuts a grid of parting lines which are used to separate the part when it is completed.

Scene I-37: F: 00-28-27	Part models are strong and commonly used directly as mold patterns or to develop secondary tooling.
Scene I-38: CD: 09-15-26	Today, Rapid Prototyping systems are helping manufacturers close the loop from art ... to production part ... in record time. For the entire part development cycle, including
Scene I-39: U: 03-21-15	design verification ...
Scene I-40: U: 02-15-00	limited testing ...

Scene I-41: F: 00-18-14	prototype tool making ...
Scene I-41: CD: 09-15-26	and real-world application testing.
Scene I-42:	Use of Rapid Prototyping has helped reduce time and costs by 30 to 95 percent. In the initial Design Verification phase of the development process,
Scene DV-1: U:02:-10-04	
Scene DV-1a	RP models ...

Scene DV-2: U: 03-15-13	or prototype parts generated from RP pattern molds ...
Scene DV-3: L: 11-14-00	can be checked for form, fit, function -- and manufacturability. This can trim the manufacturing review process from weeks to days ... and help catch potential design problems early, before any costly investment in hard tooling.
Scene DV-4: F: 00-00-43 **GRAPHIC:** **Sean O'Reilly** **Principal Mfg.** **Eng. Specialist**	The advantages of RP part models for Design Verification is clearly demonstrated at Ford Motor Company's Alpha Center.
Scene DV-5:	(00-00-44 to 00-01-52)

Scene DV-6: F: 00-03-26

Look at this drawing and in 30 seconds or less tell me what part that is a drawing of. Now that your 30 seconds are up, and you have answered that question ... now, from this drawing, figure out for me how I'm going to fixture this thing when I want to drill this hole. And how am I going to clamp it when I want to bore out this chunk of it? And what is the material handling, the dunnage, going to look like for that part?

Scene DV-7:

If you think those are difficult questions, they are. But the fact of the matter is ... is that's exactly how we do business today. This is the normal ordinary means of communications of part information from engineer to engineer -- engineer to people who have to make parts.

Scene DV-8

The Speed Scientific School, located at the University of Louisville, in Louisville, Kentucky, serves members of a Rapid Prototyping consortium.

Scene DV-9: U: 02-12-00	Here, DTM's Selective Laser Sintering -- or "SLS" -- process is used to create tough plastic parts...
Scene DV-10: U: 02-09-11	...and wax patterns for producing investment-cast metal parts.
Scene DV-11: U: 02-13-09	SLS models of nylon or polycarbonate -- both strong and machinable thermoplastics -- are used for verifying new part designs.
Scene DV-13: U: WS DTM MACHINE	At the Speed Scientific School, the SLS process can reduce the time required to achieve investment-cast metal parts from weeks, to days.

Scene DV-14:
GRAPHIC:
Tim Gornet,
Computer-Aided
Engineering
Consultant

(03-03-20 to 03-03-47)
Since you are able to use the actual investment casting wax within the machine itself, you're able to produce parts of ... especially very complex parts very rapidly. If you had to go through normal conventional means where you had to make a mold to produce a complex part, that could take weeks to be able to produce that mold to make the investment casting wax parts. By using this method you are able to go directly from your CAD model to that complex part made out of wax for casting.

Scene DV-15:
WS INVESTMENT
CASTING

(03-05-06 to 03-05-46)
The wax pattern from the rapid prototyping machine would then go to an investment casting house, or to your own internal investment casting facilities, for coating with a ceramic slurry for the investment casting process. After that has dried, it would then be fired and then the casting process would take place. The time and turnarounds that we've been able to achieve working closely with a local investment casting facility has been in a matter of days. From going from the CAD model, we generally have the investment casting wax part within the next day to a day and a half. We can then take that to the casting facility and generally return parts within three days to five days after that time period.

Scene DV-16: U:
02-09-11

The investment castings produced from the initial CAD design serve as fully functional, and testable, prototype parts.

Scene DV-17:

(03-07-10 to 03-07-36)
The advantage of the investment casting wax part is that, when you do have it cast, you cast it out of the actual material that you will be using in the final production of that part. So it can be subjected to any of the types of testing that your final part would go into -- whether that would be just form-fitting-function testing, or assembling it and actually putting it through the paces of whatever the normal production part would receive.

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Scene DV-18: L:
11-17-40

Another RP process for getting quickly to investment-cast metal prototype parts is...

...the QuickCast modeling program by 3D Systems. RP models produced by stereolithography can be used directly as patterns for investment-casting molds.

Scene DV-19: C: 12-04-46

QuickCast produces a part pattern that has an external skin, but an internal open-lattice structure that is two-thirds hollow. The lighter construction allows the pattern to implode on itself ... and avoid damage to the ceramic casting shell ... during high-temperature curing in an autoclave.

Scene DV-20: C: 13-01-27

A new epoxy-like polymer build material -- XB 5170 -- also contributes to improved processing. This resin offers low viscosity in the liquid state ... and drains easily during creation of the QuickCast model.

Scene DV-21: F: 00-14-26	The solid mold pattern produced is strong and accurate ... but vaporizes completely during the shell-curing process.
Scene DT-2: Sanders footage	New "Desktop" Rapid Prototyping systems will sell at a fraction of the price of full-scale systems ... and be compact and safe enough for use in the office.
Scene DT-3: Sanders footage	Using CAD input, the desktop systems will serve, as "printers" of three-dimensional parts, or...
Scene DT-4:	...for "faxing" a part to different locations, allowing fast collection of design data from around the world.

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Scene DT-5: U: 01-01-02 **GRAPHIC:** **FORD ALPHA MFG. DEVELOPMENT CENTER**	Desktop systems are part of an emerging vision for future engineering at Ford Alpha Manufacturing Development Center in Detroit, Michigan.
Scene DT-6:	Here, Ford is exploring all of the RP processes--each tied to pliable CAD data in what Ford calls "Free Form Fabrication,"
Scene DT-7: F: 00-21-30	The operation also includes a variety of mold-making and casting methods, as well as capabilities for conventional CNC machining.

Scene DT-8: F: 00-18-14
Peter talking low

By learning to select the best process for a particular objective, Ford hopes to develop new products faster and more cost-effectively.

Scene DT-9: F: 00-05-30
GRAPHIC:
Peter Sferro, Manufacturing Engineering Consultant

(00-08-22 to 00-09-27)
What we put together here at Ford Motor Company Alpha ... we put together an environment where we have several different mathematical CAD modeling systems feeding into a various array of Free Form Fabrication technologies.

Scene DT-11: F: 00-04-27

We have Stratasys, we have stereolithography, we have DTM, we have the Helisys system, and we have access to a Cubital machine. What we try to do here is to allow engineers to look at their problem, model that problem, and they themselves have to choose a machine that they feel comfortable with to produce it.

Scene DT-12: F: 00-23-40...F: 00-24-00

Once produced, they either change their model, or they have the ability to take it out to several other downstream operations so that they can actually materialize the final part. We have things like vacuum casting, we have spin casting, and we also have a foundry in-house that allows us to do aluminum and iron and also now to do investment casting. So we are trying to create an environment where the engineer is actually being put into a garage, where he can play with all of his parts, conceive it, and then build it.

Scene DT-13: STRATASYS footage shot at SME

Ford sees Desktop -- or office -- Rapid Prototyping systems as an integral part of the total engineering environment.

(00-09-40 to 00-10-16)
We see the Desktop Free Form Fabrication device as an immediate reinforcement and validator for initial concepts of the engineers. We expect it to be very low-cost, rather rapid ... doesn't have to be too accurate initially ... but what we really want it to be is a printer, so that the engineer can actually conceive it and then play with miniaturized models at his desk ... so that he can sit there and try to conceive different variations of ideas or methodologies as accomplishing functionality of the object that he is trying to produce.

Scene DT-14:

Peter on camera

(00-10-26 to 00-11-13)
We see a global environment being put together for engineers. We'll actually have virtual engineering teams from around the world. The Desktop will play a critical part in this here global network as the connection with the larger systems. One of the things that we don't know right now is the sourcing of any of the downstream operations. By allowing the Desktop to be utilized in the design, and fill the touch, feel, form, fit of a design ... and then the larger systems -- the ability to bring to reality the full-scale models of these, and then tooling or physical parts ... we now can build these things, virtually "fax" them anywhere in the world, have them tested there at engineering stations, then built and produced at other manufacturing

facilities around the world.

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Scene DT-15: Sanders Model maker footage	One of the first true Desktop systems is being used at Metal Casting Technology, Milford, New Hampshire, an R and D cooperative between Hitchiner Manufacturing and General Motors.
Sanders footage Scene DT-17:	Using a patented 3D plotting process, the Model Maker builds parts in layers by on-demand jetting of a non-toxic proprietary thermoplastic.
Scene DT-18:	Parts are produced to a dimensional accuracy of 2 mils or better and a surface finish as fine as 65 micro

inches. The parts can be used directly for design verification, or as investment casting patterns for producing metallic parts in almost any alloy.

Scene T-1: U: 02-01-38

While most desktop systems are still in development, full-scale RP processes are contributing in important new ways to faster completion of the product development cycle.

Scene T-2: U: 02-12-00

One example is the use of tough nylon parts produced by the selective laser sintering process.

Scene T-4:
GRAPHIC:
Tim Gornet

(03-08-41 to 03-09-04)
Where we see advantage of the nylon first is that you are getting the part directly from the machine. So it is coming directly from the CAD model without

having to go through another secondary operation to receive the parts. The nylon materials are very durable material: it handles snap fits very well, as well as higher temperatures that cannot be achieved with some of the other materials.

Scene T-5: U: 02-12-00

(03-09-56 to 03-10-39)
Our members that are using the parts use them for a number of different reasons. Many of them are using them as simple communication tools. When they designed a new part, they needed something that they could talk about in design reviews, or to show to marketing representatives to see if the part is what they are really trying to produce.

Scene T-6: U: 02-13-09

It's also being used for, I would say, form and fit -- for testing assemblies, or for testing new products in a current assembly where they would be mating with existing parts ... as well as, let's say, advanced testing.

Scene T-7:

We're aware of some testing going on with nylon parts where our nylon parts are being subjected to temperatures over 150 degrees in water.

(03-10-49 to 03-10-58)
The nylon material itself, due to its material properties, does have a fairly high heat deflection temperature, and it is a very durable material.

(03-11-09 to 03-11-13)
I think it would stand up very well to extended exposure at these temperature levels.

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Scene T-8: C: 12-02-00

Performance testing of a SLA Rapid Prototype part was dramatically demonstrated by Chrysler Corporation's Advanced Engine Development Group.

Scene T09: CH: 00-01-20

Here, a prototype intake manifold for a new Minivan 2.4-liter engine was mounted on an engine and run for six hours.

Scene T-10: C: 12-04-04

Components of the large SLA part were produced on 3D Systems' biggest unit, the SLA 500. The build material was the standard acrylic polymer used with this machine -- which offers good strength and temperature-resistance.

Scene T-12:

(12-09-35 to 12-09-53)
The manifold is basically in two pieces. There are the basic plenum runners, which is what conduct the air into individual cylinders, and then there is a flange or plate, we call it the lower intake manifold, which houses the injectors, and it also houses a passage for water out of the head to the radiator.

(12-11-15 to 12-11-54)
What we had to do, this is the lower manifold, or the injector housing flange, and this face right here butts up to the head, which is fairly hot, and more importantly, this conducts the water out of the head at 15 psi and 220 degrees Fahrenheit or so to the radiator. You can see the thermostat housing is right here. This material, or any stereolithography, can't handle that. So what we did is, we built it in stereolithography and then shot it in aluminum, and that worked up just perfectly.

(12-11-58 to 12-12-36)
The manifold itself handled the temperatures quite well. You can see some discoloration here. I don't know if that will show up so well, but there was some

discoloration from the blow-back from the cylinders. There is some amount of hot gasses that do make their way back into the manifold when the pressure in the cylinder is higher than the manifold pressure, but you can see it was very, very minor. We also put a thermocouple in between the flange and the manifold near one of the runners and it only measured 140 degrees Fahrenheit, which was well within the bounds of safety for this thing, and it ran and ran, wide-open throttle, part throttle, no problem.

Scene T-13: C: 12-05-40

A major advantage of the RP prototype is that it is an exact replica of the production manifold design. Unlike previous test manifolds, cobbled together from tubing and steel plate, the RP part provides reliable flow performance data.

Scene T-14: C: 12-07-31

If design changes are needed, updates can be made in the CATIA solid model ... and a new SLA part produced in a matter of days.

Scene T-16:	(12-15-15 to 12-15-50) The tests we wanted to run were what we considered to be basic performance tests, with an emphasis on wide-open throttle. Manifold design gets very particular when you are trying to trade off full power at rated speed versus torque at lower speeds for given applications. Whether it is a minivan, or a car, will require different applications as well as the transmission. So we have to interplay the runner lengths and the runner diameters and the plenum volume to get the specific part characteristics we are looking for. So there is a lot of work involved, a lot of iterations.
Scene T-17: CH: 00-02-02	For Chrysler, a big question was whether the RP manifold would stand up to testing this rigorous?
Scene T-18: CH:00-04-22	(12-15-52 to 12-16-22) What we did was we put it on the test stand, which the engine was mounted to an electric dynamometer, and we ran at wide-open throttle first ... and beyond the normal torque and fuel and airflow

measurements, we put a thermocouple in between the flange and the runners to make sure we weren't going to get ourselves in trouble. And after that testing was done, we went in and looked at part throttle performance, just very briefly, type stuff you would do at 60 mph or 40 mph in your car, and then we looked at idle.

Scene T-19:

(12-17-21 to 12-17-38)
We were very impressed. We didn't think it would last six hours, and we gave it all kinds of abuse. It doesn't work for under hood; I wouldn't recommend this for doing in a car yet because hood temperatures get pretty high. But for dynamometer tests, it told us everything we needed and then some.
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Scene TL-6: G: 02-02-27

At General Pattern Company, Blain, Minnesota, rapid prototypes are also being used as a first step in the manufacture of more durable tooling that can generate thousands of highly accurate part copies in tough and testable

	materials.
Scene TL-7 G 02-22-10	General Pattern serves customers in the automotive, computer, and medical equipment industries.
Scene TL-8: G: 02-16-25	The Cubital Solid Based Curing method of rapid prototyping is their first step in creating Liquid Injection Molds from a tough epoxy-type composite material.
Scene TL-9: G: 03-07-53	This tooling can produce up to ten parts a day from special fast-set, temperature-resistant polyurethane resins.

Scene TL-10:
Robert Granger
General Pattern
Vice President

Scene TL-11:

(01-03-17 to 01-04-03)
Essentially, we receive a CAD database in some CAD format. It might be ProEngineer, which would be our preferred media, or it might be CATIA or some other form. We need to take that data and convert it to an STL file, which is what the solid, or rapid prototyping, system understands. With that STL file we convert the data to an acrylic model.

Scene TL-12:
G:02-23-08

We extract that model from the model-making machine and, with a limited amount of hand work, pass that through a cast molding process and ultimately deliver urethane molded parts to our customer.

Scene TL-14:

(01-06-02 to 01-06-39)
The true advantage to the customer is multiple. One is ... in today's marketplace time is money and we are typically 20 percent of the time to create a LIM mold than it would take to create a conventional steel mold. So we have saved an enormous amount of time. In addition, we have saved an enormous amount of money. We have created something that is 25-percent of the cost of what you would pay for production tooling. So you have the ability to convert your design to usable product in a very short period of time and get that product into the marketplace.

Scene TL-15: G:
02-07-07

The Cubital process is known for its throughput capacity -- an important consideration at General Pattern.

Scene TL-16:

(01-09-19 to 01-09-45)
The Cubital process is extremely good at making large parts that are very complex. And because no supports are required during the model development or the CAD database development process, we are allowed to make multiple parts

simultaneously. We can make as many as 25 or 30 different models at the same time in less than 24 hours.

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Scene TL-17: L: 11-08-39

Laserform, Incorporated, Auburn Hills, Michigan, is a service bureau that produces RP parts by stereolithography for the major auto companies and their first line suppliers.

Scene TL-18: L: 11-11-25

Eighty- to ninety-percent of the models serve as patterns for secondary tooling used to produce prototype parts in polyurethane.

Scene TL-19: L: 11-14-32

These parts, in turn, are used to verify designs and, in many cases, for some levels of application testing.

Scene TL-21: L: 11-15-56

(08-10-18 to 08-11-48)
Accuracy is very important, especially due to the fact that there are job shops like us that use it for secondary tooling. Now, if you have, if you are utilizing this pattern for a relatively small part, let's say a 10 times 10 times 10 inch part, you really don't have to comprehend any expansion for material shrink with, for example, polyurethane.

Scene TL-22:

But if you decide that you are going to build a longer part, like a body side molding, or a rocker panel, using rapid prototyping, and we happen to have a couple of examples in our shop right now, then you have to expand those, because you do have about two to three thousandths in shrink inch per inch with even polyurethanes.

Scene TL-23:

If you are going the next step, and you are creating soft tooling for injection molding off a rapid prototyping pattern, then it is very important to comprehend the shrink in the epoxy and the aluminum, which is around 11 thousandths inch per inch, and then for any type of polypropylene or ABS, which could be seven to eight thousandths inch per inch. So you might plug in 17 to 20 thousandths inch per inch for it to comprehend your shrink for that type of application. So accuracy is very important, and scaling is very important. I might just add with stereolithography you can either do it at the machine, you can do it at the slice computer, or you can expand in CAD. We choose to do it right at the machine.

Scene TL-24:
L:11-14-52...L:11-15-39

In the stereolithography process, the new epoxy-like XB 5170 build material -- designed primarily for use with the QuickCast modeling program -- has made possible levels of accuracy far beyond those obtained with previously used acrylate materials.

Scene TL-25:	(08-17-17 to 08-18-50) We began to use it not for building hatch-type QuickCast patterns, but for using what is now called the Aces build style, or building the part using Star Weave ... but using the epoxy resin which really hadn't been tested yet. So we saw some dewetting, we saw some delamination, there were some early problems. Aside from those problems, we quickly uncovered that these parts were very accurate and that you didn't need nearly the amount of shrink calculation that you did for the acrylates.
Scene TL-26: L: 11-09-41 or L:11-10-08	Our model makers really liked the material because it seemed to bench easier, and for longer parts that were like a thin wall section -- 2-1/2 mil wall section over the 10 inch dimension -- you didn't get warpage. So you didn't get a lot of what we call knit lining that would have to be heated and corrected by our model maker using conventional templates.
Scene TL-27:	Now, that also led to some real

interesting applications for castings, and we are now using this process and the QuickCast software to build the patterns that are now used for tooling -- cast aluminum tooling for some of our OEM customers.

(08-19-22 to 08-19-42)
The introduction of the 5170 as a Beta, and now as a release, product really changed or almost revolutionized stereolithography -- not only for castings, but for the overall accuracy that it now provides. It is now just a monumental improvement in accuracy.

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Scene TL-28: L: 11-17-40

Recently, Ford Motor Company made use of the new stereolithography build material and QuickCast modeling process to test the feasibility of a fast path to hard tooling -- now often called "Rapid Tooling."

Scene TL-33:

(09-01-49 to 09-02-41)
Well, when we started the project, we started off with a 2-D drawing that was

generated in AutoCAD. We took that drawing and created a solid model in ProEngineer.

Scene TL-34:

We made prototype parts based on that solid model on the SLA machine, and effected the design changes throughout that process three different times.

Scene TL-35: CD: 09-16-00

Once we were satisfied with that design, we used a package in ProEngineer called ProMold. In that package you create what is called a workpiece. When you get that workpiece situated the way you want, you embed the solid model of the part in the center, create parting lines, and then separate those two halves.

Scene TL1-36: CD: 09-16-00

Then those two halves are sent to the stereolithography machine, and built as stereolithography patterns, or QuickCast patterns.

Scene TL-37:

(09-04-14 to 09-04-20)
We went to Howmet, out in Whitehall, Michigan, to actually investment-cast the QuickCast patterns.

(09-04-41 to 09-05-08)
Once Howmet gets those QuickCast patterns, they take them and dip them in a ceramic slurry and build up successive thicker layers, or coats, of ceramic, and then fire that, burning out the QuickCast patterns inside and simultaneously curing up that ceramic, allowing any type of metal material to be poured in, and then, obviously, that cooled, and the ceramic removed.

(09-09-02 to 09-09-52)
Conventional tooling would have taken us 18 weeks to cut the tool. QuickCast tooling took approximately six weeks. There was a week or two -- and that is compressed -- there was a week or two time of education, learning ProEngineer, learning QuickCast: so there was some education backed in that time. But the compressed time of the project was six weeks. So the time savings are obvious there.

Dollar savings ... the original tools cost $33 thousand. The QuickCast patterns cost $18 thousand. Future savings could be realized by incorporating all the cooling lines and the injector pin lines, and making sure that surface finish is at the best quality of the investment casting capabilities.

Scene TL-38:
CD:09-17-31

Not all of Ford's objectives were met in its first trial of a Rapid Tooling process. Still, QuickCast did prove its ability to meet a key Ford requirement for prototype parts.

Scene TL-39:

(09-07-01 to 09-07-49)
The original goal of the project was to achieve production quantities. We didn't do that, and the reason we didn't do that was because of the surface finish on the part.

Scene TL-41:	But these were functional prototype parts, so it did provide us with prototype tooling for the project.
Scene TL-41:	(09-08-12 to 09-08-36) Prototype parts that Ford Motor Company is most interested in is "early durability" parts. A part that you can put on a car, in production material, and test in real-world conditions. These parts met that requirement. We were able to mount them in a car, do some water testing, test them on the road, in real-world conditions. So they provided us with "early durability" testable parts.
Scene TL-42: CD: 09-17-31	In summary, Ford took these steps to get to hard tooling:

CD: 09-17-31: stop 1	Optimized the CAD part design ...
CD: 09-17-31: stop 2	Produced a RP part model ...
CD: 09-17-31: stop 3	Created a CAD design for the injection-mold core and cavity inserts ...
CD: 09-17-31: stop 4	Produced RP patterns of the core and cavity inserts ...

Cd: 09-17-31: stop 5:	Investment-cast the injection-mold tooling -- shown here in reduced size ...
CD: 09-17-31: stop 6	Injection-molded the prototype part in a production material ...
CD: 09-17-31: stop 7	and assembled the part -- in this case, the windshield-wiper motor cover -- for functional testing.
Scene TL-43: CD: 09-17-31:	In a further trial of Rapid Tooling techniques, Ford is currently producing the same injection-mold tooling using DTM's RapidCasting method.

Scene TL-44:	In this case, the Selective Laser Sintering process is used to create a positive part model, and core and cavity mold patterns, from a polycarbonate material.
Scene TL-45: CD: 09-17-31: stop 6	With either the QuickCast or RapidCasting process, the A2-steel injection-mold tooling produced can generate up to 250,000 production plastic parts. **FADE TO BLACK**
Scene TL-46:	An even faster RP process for producing injection-mold tooling is now being tested at DTM Corporation, developers of the Selective Laser Sintering method of Rapid Prototyping.

Scene TL-47:	The first step in this process, called RapidTool, is the selective laser sintering of "green" core and cavity tooling from a metal composite that is 75% iron and 25% polymer.
Scene TL-48:	The green parts are then post-processed in a furnace. Here, the polymer binder is burned out and the metal powders are bonded together through traditional sintering mechanics. At this point, the resulting "brown" parts are durable, but also porous.
Scene TL-49:	In a third step, a second metal like copper, serving as an infiltrant, is added to the furnace. This metal turns liquid with elevated temperatures, and infiltrates the brown parts via capillary action. The result is fully-dense tooling components.

Scene TL-50:

Total cycle time for producing finished RapidTool injection-mold tooling can be less than one week. With proper handling, the tooling can produce more than 50,000 parts.

Scene TL-51:

Today, Rapid Prototyping processes may even be close to bridging the gap between Rapid Tooling and Rapid Manufacturing.

Scene TL-52:

One of the most interesting new concepts is the Direct Shell Production Casting -- or DSPC -- process developed by Soligen, Incorporated, North Ridge, California.

Scene TL-53:

The DSPC system does away with part patterns completely. Instead, it directly produces a ceramic mold for metal casting in a matter of hours ...

Scene TL-54:

leading to fully functional metal parts of any complexity and any castable metal in just two to three days.

Scene TL-55:

To build a casting mold, the DSPC system's Shell Design Unit first converts a CAD solid model of the desired end part into its negative:
a digital model of a casting mold. A tree structure is added for required gating and multiple mold copies.

Scene TL-56:

The mold digital model is then processed with proprietary software to generate a series of cross- sectional slices to build ...

Scene TL-57:

the Shell Production Unit. Here, a roller spreads a thin layer of ceramic powder on the surface of a vertical piston.

An ink-jet-type printhead then moves across the piston in raster fashion, ejecting tiny drops of binder onto the powder layer to glue the particles together. This process is repeated until all cross sections have been printed one on top of another.

Scene TL-58:

When the build process is completed, the mold is removed from the bin. After cooling, the unbound powder is cleared away. This yields a finished three-dimensional ceramic mold ready to accept molten metal for casting.

Scene TL-59:	Metals successfully cast in DSPC molds include aluminum, cobalt-chrome, stainless steel, tooling steel, bronze, copper, and Inconel.
Scene C-1: G:01-02-27	With these kinds of developments, and more, Rapid Prototyping promises to play an increasingly important role in enhancing product-development and manufacturing productivity.
Scene C-2: L: 11-12-54 Terry Wohlers Rapid Prototyping Association	Terry Wohlers is a consultant on Rapid Prototyping, and chairman of the Board of Advisors of SME's Rapid Prototyping Association.
Scene C-3:	We asked him to give us an overview of

the role of Rapid Prototyping today ... and forecast future developments.

(10-16-28 to 10-16-51)
What you really have to do is look at how products are brought to market and delivered to the customer. You start out with the conceptual design and then you end up with delivery to the customer. Right now, the market that is being served by the rapid prototyping system vendors is the modeling and prototyping patterns for secondary tooling, but there is a whole lot of activity that goes on before and after.

Scene C-4:

(10-17-33 to 10-18-04)
If you look at only the CAD installations being used for mechanical part design, the number totals well over 500,000 units. If you add up all the PC units and all of the applications out there, there is probably over one million units worldwide. So, I expect that these vendors will address these markets, and some have already, such as Stratasys.

Scene C-5:	Then you have the production tooling going on and the part manufacturing, companies such as DTM and Soligen, and others addressing that end of the market.
Scene C-6: L: 11-10-56	(10-21-54 to 10-22-21) Most systems are being used for design verification, for producing patterns for secondary tooling. In fact, that is how you can most easily justify the cost of purchasing a rapid prototyping system -- is for producing patterns for secondary tooling, whether it is silicon rubber, or plaster, or perhaps sand casting. There is all kinds of those processes available to marry to the rapid prototyping process.
Scene C-7:	(10-26-56 to 10-28-01) As more people enter the market, more systems enter the market, then the stereolithography will shrink in size.

Scene C-8:	What other technologies will be available? The laminating types of process, such as Laminated Object Manufacturing ...
Scene C-9: F: 00-16-50	the thermal extrusion ...
Scene C-10:	and the jetting technologies that are based on the ink jetting process. Why is that? Because you can package these systems potentially very small, they are clean, and they don't, for the most part, contain any very expensive items. So that combination could become very attractive to a lot of users around the world.
Scene C-11: U:02-13-09	With exciting developments still to come, Rapid Prototyping systems and services

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are available RIGHT NOW to help you dramatically reduce the time and costs of your product development cycle.

Read the literature, and examine the options. There may be a fit with your own operations that can make you more fully competitive ... in our fast-paced, demanding, global economy.

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