Manufacturing Insights

Rapid Manufacturing

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SCENE 1. CG: FBI warning white text centered on black to blue gradient	WARNING Federal law provides severe civil and criminal penalties for the unauthorized reproduction, distribution or exhibition of copyrighted video media © SME 2007
SCENE 2. SME logo with music	
SCENE 3. CG: Title of video CG; company logos fly in and hold DR – should we seek to get all the logos? I think it could be a good way to show that this isn't one person's view. If yes, you or me to make contacts?	MUSIC UP AND UNDER Manufacturing Insights, Manufacturing Engineering Magazine's video series for process improvement. This program will explore the possibilities created by rapid manufacturing and the role that it is, and will, play in design and manufacturing processes. During SME's [1] RAPID conference and exposition, we interviewed industry experts to gain insight into rapid manufacturing. The following people shared their thoughts with us: Carl Dekker {deck-er}, president of Met-L-Flo {met-elal-flow}, Incorporated. Richard Hague {Hayg}, from Loughboro {luff-bor-

	oh} University Michael Siemer {See-mer}, president of Mydea {my-dee-uh} Technologies Brent Stucker, from Utah State University Dr. Chris Sutcliff, a lecturer at the University of Liverpool Michael Shellebear {shell-a-bear} and Jim Fendrick from EOS {E – O – S} And Greg Morris, COO at Morris Technologies, Inc. Next we traveled to Advatech {ad-vuh-tek}, a division of Butler Tool and Design, where Jim Butler, president, showed us his company's rapid manufacturing process. We also interviewed Ian Campbell, Neil Hopkinson and Phill Dickens on the campus of Loughboro {luff-boro} University. These men lead the efforts of a 46-person research group dedicated to rapid manufacturing. -- TOUCH TO BLACK --

SCENE 4. Stock footage of CAD data, machine, part coming out	NARRATION (VO): Rapid manufacturing is the process of going directly from a digital representation of a part to a final product via rapid prototyping technologies.

SCENE 5. Stock footage Side-by-side: molding machine (good shot of tool) and an RP machine	NARRATION (VO): Without molding, machining, casting, forming or fabricating, companies can produce products, sub-assemblies and components directly from 3D data. Unrivaled by traditional manufacturing methods, rapid manufacturing creates new opportunities and offers unmatched benefits.
SCENE 6.	Ian Campbell (IC) {Ian Campbel.mp4 21:48:35:20-21:48:45:16} - The unique aspect of rapid manufacturing is the fact that it creates components by adding material, and this is why it's sometimes called additive manufacturing (105).

SCENE 7. What is the point here. Change this to better explain the issues and forget talking about sME>	NARRATION (VO): SME's technical community has adopted direct digital manufacturing as the official term for rapid manufacturing. Yet, rapid manufacturing and other terms, such as additive manufacturing, are commonly used throughout industry. Just as the technology and applications are evolving, so is the terminology. The name "rapid manufacturing" is being replaced by "additive manufacturing" and "direct digital manufacturing" in order to distinguish the process from others that are fast but do not employ additive technologies. Amongst the alternative names that have been proposed, the Rapid Technologies and Additive Manufacturing technical community endorses direct digital manufacturing as the preferred name for the process.
SCENE 8.	NARRATION (VO): What rapid manufacturing encompasses is also a point of discussion.

SCENE 9.	Carl Dekker (CD) (Carl Dekker.mp4 2:14:46:28 – 2:15:01:24} You can be looking at it as rapid manufacturing being the manufacturing of a tool used to be able to produce end product for resale, or you could look at it as rapid manufacturing being used as the direct approach to directly manufacture an end product (58a).
SCENE 10. Does the viewer care about this? What is the valuvevalue in knowing this. Leave SME out of this. Viewer may not care, but they should. We are talking about 2 very different things. Also, RP companies promote RM as a tool-based process. Many argued that we needed to include this in the video!	NARRATION (VO): While some consider the acceleration of tool or pattern production to be rapid manufacturing, these indirect processes do not adhere to the concept of direct part production. For this reason, and since theAlso, the processes, advantages and challenges are quite different when producing tools or molds, so the scope of this rapid manufacturing discussion is limited to direct part production.SME's technical community does not include tool production in the scope of rapid manufacturing.
	{pause}
SCENE 11.	NARRATION (VO): Rapid manufacturing has been successful for many companies, but it has not become a mainstream process. However, it is predicted to grow rapidly.

SCENE 12.	Richard Hague (RH) {Richard Hague.mp4 2:02:56:29-2:03:11:19} I suggest it is going to pick up greatly in the next few years. We're already seeing it being very popular for niche, high value areas, but I think we're going to see that migrating to other areas in the future (53).
SCENE 13.	Michael Siemer (MS) {Michael Siemer.mp4 1:46:04:29-1:46:18:11}The interesting thing is that it's already changed manufacturing. We're starting to see more examples of direct digital manufacturing and something called mass customization, where you can customize a part individually for a person. {1:46:32:12-1:46:35:19} it's just going to be a matter of time when it grows exponentially (39).
SCENE 14. Stock footage of traditional manufacturing	NARRATION (VO): As it gains momentum, rapid manufacturing is envisioned to be the next industrial revolution.predicted to alter longstanding manufacturing processes, practices and procedures.
SCENE 15.	(RH) {2:03:38:17-2:03:45:23}The advantages and benefits of rapid manufacturing are enormous. They fundamentally change the way we make things (54).

SCENE 16.	Jim Butler (JB2) {Jim Butler Onsite.mp4 AUDIO PROBLEM} The potential for rapid manufacturing is incredible. I think it's going to be another revolution. It's going to allow the common man to go into production with a design that otherwise would not be feasible with conventional tooling approaches. you're going to see many more things in production that you never would have seen before, and you're also going to see the functionality of your products and components be much better than it ever was before, because designers are going to be able to design for functionality rather than machinability. That's going to be revolutionary. (92)
SCENE 17.	(RH) {2:09:37:19-2:10:02:01}it is just a fantastic opportunity. I think we use the term "the next industrial revolution for a digital age," and it really is. We have such a profoundly different way of making things than we historically have, and that enables us to change the design, change the implementation, change the way we make things. (103a).

SCENE 18. Have used the saying "Next industrial revolution to many times at this point.	NARRATION (VO): While the opportunities are boundless, there are obstacles that must be overcome. But, when they are, the next industrial revolution will be ushered in.processes will change; new methods will evolve; and innovation will sweep throughout manufacturing.
	{pause end of intro}
SCENE 19.	NARRATION (VO): Rapid manufacturing is a process that uses additive fabrication technology to produce end-use items. It is unique in its ability to take 3D CAD data and convert it to finished goods without tooling of any kind.
SCENE 20. CG: List of key points overlaid over machine in operation video - 3D CAD design - Export STL - Build part - Finish to spec	NARRATION (VO): The process is simple, efficient and automated... - Begin by designing the part in 3D CAD - Then export an STL file - After processing the data, build the part using additive fabrication machines; otherwise known as rapid prototyping - Finally, finish the part to specification

SCENE 21. Stock footage of machining a mold/tool + long shot of manufacturing operation	NARRATION (VO): This eliminates the time, expense and labor for designing and producing tooling. It also minimizes the number of steps in the manufacturing process and the associated labor. But these are just a few of the many advantages offered.
SCENE 22.	(CD) {2:15:07:08-2:15:22:22}opens up the ability to consolidate parts, to be able to make assemblies on demand. If any design changes come up, you can automatically change it in the electronic data, and it carries forward .(58)
SCENE 23.	(JB1) {1:20:05:23-1:20:17:23}It sort of brings manufacturing almost to the common man. No longer do you have to have several hundred thousand dollars to tool up for a project. {1:20:29:17-1:20:40:07} now the "common man" can dream up a part, dream up a product, and it can be built with little or no investment in tooling. (18).
SCENE 24. Stock footage of (in use) a jig, fixture or assembly tool/aid. Carry into next scene	NARRATION (VO): Although the focus is often on sellable goods, an equally important application is the production of items used in manufacturing and assembly processes.

SCENE 25.	(JB2) { AUDIO PROBLEM }The more complex it is, the better the fit for this technology. That's especially true for tooling and fixtures, drill fixtures, drill jigs, and that sort of thing (89).
SCENE 26.	NARRATION (VO): Rapid manufacturing is truly unique. It eliminates the constraints that traditional processes impose on design and manufacturing.
SCENE 27.	(JB1) {1:18:48:05-1:18:56:13}We don't have the manufacturability as a deciding factor of the cost. It's purely what the human mind can imagine. {1:18:59:27-1:19:22:29} You can now design a part for perfect functionality, and we can build it. You're going to see the performance, the reliability, the capability of products improved just because of this technology. It's not only rapid manufacturing, it's just the capability of this technology that's so fantastic (17).
SCENE 28. Stock footage of parts coming out of mold (or similar) at high rate of speed	NARRATION (VO): Even though it holds so much promise, rapid manufacturing should be viewed as an alternative, not a global replacement for established manufacturing processes.

SCENE 29.	(GM){2:30:38:07-2:30:53:01}I don't think rapid manufacturing is going to replace all the machining technologies or stamping or injection molding technologies that are out there, that's not going to happen, certainly not in our lifetime.
SCENE 30. Stock footage of injection molding, die casting, stamping	NARRATION (VO): Experts state that currently Rapid rapid Manufacturing manufacturing is ideal for small lot production, not high volume manufacturing common with injection molding, and die casting and stamping operations.
SCENE 31.	Brent Stucker (BS) {Brent Stucker.mp4 1:53:35:05-1:53:46:03}I think initially it's going to be high complexity, relatively smaller volume, industries that are going to adopt rapid manufacturing. {1:53:47:11-1:53:59:21} The larger you get, the less competitive we are in speed with traditional tool based production processes, like injection molding or stamping or other things that require tools. {1:54:26:15-1:54:35:19}Rapid manufacturing is never going to be able to compete in those hundreds of thousands of volume, at least any time in the foreseeable future, if it's identical every time. (45)

SCENE 32. Machine shots RAPID B-roll (24:34) FDM Titan Lboro b-roll (6:10) SLS machine	NARRATION (VO): Additive fabrication technologies that produce "functional" parts from thermoplastic materials are likely candidates for rapid manufacturing. Examples include: Laser sintering Fused deposition modeling
SCENE 33. Lboro b-roll (6:11) SLS machine	Neil Hopkinson (NH) {Neil Hopkinson.mp4 21:58:32:27-21:58:47:01}The predominant technology that I use for rapid manufacturing is selective laser sintering, There are a number of reasons for this. Firstly, the mechanical properties of parts remain stable over time, and this is important for manufactured products. (116)
SCENE 34. Lboro b-roll (2:33)	NARRATION (VO): However, functional is a relative term that is determined by the application. For example, one of the most cited rapid manufacturing success stories is the production of in-the-ear hearing aids, which uses the stereolithography {stair-ee-oh-lith-og-ra-fee} process and its photopolymers {photo-pol-a-mers}.

SCENE 35. Rapid b-roll (:38) DMLS machine sparking and/or (3:44) shot of M270 (DMLS)	NARRATION (VO): With recent advances, the direct metal technologies also hold high promise in rapid manufacturing applications. These technologies include: Electron beam melting Direct metal laser sintering Ultrasonic consolidation Selective laser melting
SCENE 36.	(CS) {1:12:14:28-1:12:30:12}The vast majority of our manufactured components contain some metal part, and that metal part hasn't been able to be manufactured by these techniques until two to three years ago, and it is only now that those techniques are maturing. (10).
SCENE 37.	NARRATION (VO): Early adopters of rapid manufacturing have been those companies with small, complex parts and low volume production needs.
SCENE 38.	Greg Morris (GM) {Greg Morris.mp4 2:26:54:23-2:27:07:09} I think starting out, lower volumes and high complexity, and the need for rapid turnaround are going to drive those industries to want to use the rapid manufacturing concept (68).

SCENE 39.	NARRATION (VO): High value and highly engineered parts in low quantities are the hallmarks of the industries where rapid manufacturing has had early success.
SCENE 40. Stock aerospace footage	Michael Shellebar (MS2) {1:31:12:24-1:31:34:00} At the moment there's a lot of interest from aerospace, because they typically have a combination of low volume production, small quantity size, very complex parts, and often very expensive traditional methods, so this is a combination of attributes which is well suited to rapid manufacturing (29).
SCENE 41. Stock medical footage Or shot from Simplant (1:22)	(CD) {2:16:45:02-2:16:59:20} Medical products, because of the fact of the high value added, like an MRI machine or some type of large medical equipment, opens up the possibilities because you don't have the volumes. You're not selling thousands (60)
SCENE 42. Stock racing footage	(JB2) { AUDIO PROBLEM }Probably the first adopters of this technology are people who are designing or have the need for very highly engineered components and products. I'm talking about the aerospace industry, I'm talking about racing, I'm talking about medical and defense. People who value performance above all else. (82).

SCENE 43.	NARRATION (VO): These industries are ideal for rapid manufacturing. But there are many other industries and applications that will benefit from the technology's tool-less manufacturing approach and the changes that it will introduce.
SCENE 44.	(MS2) {1:29:31:08-1:29:33:20} There are a broad range of advantages and benefits. {1:29:54:04-1:30:11:10} you can go very quickly without tooling to a part, within days, within hours in some cases. The cost benefit is also increasingly important, particularly for small user products, where otherwise you'd have very high costs for tooling that need to be amortized. (27).
SCENE 45.	(BS) {1:52:00:21-1:52:21:15}You can do low volume production at much lower cost than you can if you have a tooling based process. Also the tooling makes a big difference in time in that you can rapidly make a few parts directly, soon after you design them, get them out there, try them, so the time to market is going to be dramatically reduced (43).
SCENE 46.	NARRATION (VO): Rapid delivery was the key to success for one project at Mydea (My – Dee – uh) Technologies.

SCENE 47.	(MS) {1:48:41:01-1:49:15:25} One example we did recently was for Universal Studios, where they needed to come up with a design solution and implement it within one to two weeks time. We were able to come up with multiple design concepts, produce the component, which happened to be a guard for a fingerprint scanner where you enter the park. We designed multiple prototypes and produced all 50 components on a rapid prototyping machine within 1 to 1 ½ weeks time. That was a great example of rapid product development and rapid manufacturing (40).
SCENE 48.	NARRATION (VO): But the advantages go far beyond cost and time.
SCENE 49.	(RH) {2:03:38:11-2:03:45:21}The advantages and benefits of rapid manufacturing are enormous. They fundamentally change the way we make things (95).
SCENE 50. Rapid b-roll 12:41 (folding chair)	(RH) {2:03:56:19-2:04:15:05}Once you get away from having the restriction of tooling, you don't have to design for the manufacturing process you've got. What we have in the rapid manufacturing technologies is the ability to have completely unconstrained design. You have very complex geometries at effectively no extra cost.(96)

SCENE 51.	NARRATION (VO): Neil Hopkinson, from Loughboro (Luff-boro) University, offers an example that shows the benefits of rapid manufacturing.
SCENE 52. Still(s) of soccer shoe (boot 1.jpg, boot 7.jpg) Note: add "courtesy of P2L" to image	(NH){21:57:56:13-21:58:19:01} of _____ football boots. This was an opportunity where selective laser sintering technology was actually able to manufacture the football boots at a much cheaper cost than any of the other potential processes. Furthermore, the advantage of the technology was that it allowed us to make far more complicated and exciting products that were really important for this niche market area. (114)
SCENE 53.	NARRATION (VO): In a tool-less manufacturing process, companies also gain a freedom to redesign products.
SCENE 54.	Jim Fendrick (JF) {Jim Fendrick.mp4 1:38:53:17-1:39:04:21} If it's a customized product or one-off product it's very easy to change without having tooling changes occur, so it gives you a lot of flexibility in your designs (34).

SCENE 55.	(JB2) { AUDIO PROBLEM }There is a tremendous cost savings when you look at it from the point of view of the original designer evolving his design. With this technology you can build your first thought, and then test it, and then as you decide to make changes, build the second generation. Generation by generation you can evolve your part. (76).
SCENE 56. Stock footage of tool rework (e.g. welding an existing tool)	(JB2) { AUDIO PROBLEM }In the past, the last few changes you want to make, you had to ask yourself is it really worth all that expense to go through changing my tooling and changing the design. Now since it's not that expensive and it's quick, you can go ahead and evolve your design to perfection (77).
SCENE 57. Rapid b-roll (14:10) lamp	NARRATION (VO): Rapid manufacturing means lower capital expenditures, faster product delivery and the freedom to redesign a part with little consequence. It also introduces greater freedom in part design.

SCENE 58.	(CS) {1:09:42:16 – 1:09:52:08} It will empower designers to design the sort of structures they want to design, rather than being constrained by the manufacturing process. (IC){21:45:51:26 – 21:46:20:18} From a designer's perspective, the greatest advantage of rapid manufacturing is geometric freedom. Virtually any shape can be manufactured with little differentiation in cost. This means we can tailor products to an individual customer's needs whether in terms of aesthetics or indeed ergonomics. It also means designers can explore the relationship between form and function in new and creative ways (104).
SCENE 59.	NARRATION (VO): For years, the concept of design for manufacturability has been promoted. To reduce product costs, improve quality and increase reliability, product designers have been instructed to design parts with consideration of the manufacturing process' constraints. With rapid manufacturing, this is no longer true.
SCENE 60.	NARRATION (VO): Jim Butler shares one example of the design freedoms that rapid manufacturing offers.

SCENE 61. Advatech b-roll broken door mount and new RMd mount (4:40:xx)	(JB2) { AUDIO PROBLEM }The handle was previously an injection molded part. As you know, in an injection molded part you strive to keep your wall thicknesses, just so the part can be successfully molded without deforming. In this technology though, we can put the strength and put the thickness of material wherever it needs to be for that particular part function. The previous design, being injection molded, was brittle, it broke. We redesigned that part to be made with the SLS technology, put the strength where it needed to be (83).
SCENE 62.	NARRATION (VO): The full potential of the design freedom will be unlocked when the new paradigms are adopted.
SCENE 63.	(IC){21:50:12:00 – 21:50:35:26} We should be looking for products where we can add extra performance or aesthetics or ergonomics and in that way give the user something that they are prepared to pay extra for. A good example of this was the garden tools that we designed here at Lufberg, where the shape of the handle was conformed to the unique shape of an individual's hand. (107).

SCENE 64.	(BS){1:57:41:17-1:57:50:15} it opens up a ton of possibilities for integrating thermal control, electronics, and other things into an integrated structure. {1:58:13:03-1:58:27:27} All these rapid manufacturing things we're doing are where we're using unique benefits of additive manufacturing technologies that are just not possible using traditional manufacturing operations (50).
SCENE 65.	NARRATION (VO): While severing the relationship of cost and complexity makes many ideas practical, rapid manufacturing also frees companies to do the previously impossible.
SCENE 66. {requested still image of cube with lattice. Waiting for reply}	Chris Sutcliff (CS) {1:10:26:12-1:10:38:06}You can build impossible to construct geometries, impossible to construct in any other way of manufacturing, so it does empower the designer. {1:11:16:04-1:11:26:26}I'll give you an example. We create lattice(?) structures. If you look at a 30x30x30 milliliter cube of this material, it has eight million individual components. {1:11:33:26-1:11:47:06}So you can see the complexity is huge. Then we can mix that lattice(?) structure with solid materials. It's a very flexible and a very smart way to make things(9).

SCENE 67.	(BS) {1:50:48:13-1:51:00:07} People will be able to design to the end product and not based on how it's going to be manufactured driving the design. Instead what the final application is is going to be driving the design. (42)
SCENE 68. Stock footage of assembly operation (manual…people doing the work)	NARRATION (VO): Making the impractical and impossible realistic will broaden the impact of design for assembly. Unlimited complexity allows multi-piece assemblies to be consolidated.
SCENE 69.	(NH) {21:57:31:19-21:57:42:01} when using the technologies for manufacturing, we'll find that the reductions in assembly time will make a significant impact in terms of the overall costs of products that are manufactured. (113)
SCENE 70.	NARRATION (VO): Jim Butler offers an example of part consolidation.
SCENE 71. Advatech b-roll (4:41:XX) New defroster	(JB1){1:23:45:17-1:23:53:09}One example is a defroster control for a light airplane. {1:24:24:29-1:24:36:05}The old one is made up of nine separate pieces. Because of this technology we were able to design that into one piece, design out numerous problems that were with the old design (22).
SCENE 72.	NARRATION (VO): Part consolidation will decrease tooling and assembly cost. But And it will also affect other aspects of the production process.

SCENE 73.	(CD) {2:12:59:12-2:13:47:16}As some of the design concepts begin to change and start opening up the ability to look at doing consolidation of parts, products, assemblies and start building them all as single components or as a reduced number of components, now the benefits of being able to reduce service checkpoints, failure issues can be resolved or removed, and the option of being able to start minimizing the amount of assembly steps and the amount of tools needed to produce these pieces, then it becomes a question of weighing out the investment or the increased cost of doing them through direct manufacturing, as opposed to all the tools necessary, the processing, the logistics, and all the supply chain requirements for doing it through conventional manufacturing (57a).
SCENE 74.	NARRATION (VO): These benefits are exciting and the opportunities they present are fantastic. So, why aren't more companies adopting rapid manufacturing? The reason is that there are limitations with the technology and barriers that must be addressed.

SCENE 75.	(NH) {21:56:50:27-21:57:04:17}we are going to have to overcome a number of barriers. Amongst these will be perceptions of how we can use the technology, but also technical issues of material properties, material costs, and in particular, machine time and cost (112).
SCENE 76. Stock footage of some quality control operation	NARRATION (VO): Ideally suited for rapid prototyping, the additive fabrication machines produce parts that lack certain qualities of those produced from traditional manufacturing processes.
SCENE 77.	NARRATION (VO): The most apparent are tight tolerances and smooth surface finishes. Generally speaking, rapid prototyping machines cannot deliver the accuracy and smoothness that results from a process like injection molding.
SCENE 78.	NARRATION (VO): While product design can address tolerance and finish, it cannot overcome issues of process repeatability and reproducibility.
SCENE 79.	(BS) {1:55:34:21-1:55:49:05} more than anything I think it needs to become repeatable, so that when people order a part from Vendor A or Vendor B, they know it doesn't matter who they order it from, as long as they're using that process, the end result is going to be what they expect (47).

SCENE 80.	NARRATION (VO): Originally designed for prototype applications, the next generation of rapid manufacturing machines will need to accommodate the needs of a production environment.
SCENE 81. This may be to much of a sales pitch	(JH) {1:44:29:23-1:44:53:01}There are different needs for a manufacturing machine vs. a prototyping machine. EOS is designing our equipment to fit into this manufacturing realm, because we believe this is what's going to drive this industry to the next level and make it a much larger industry—not rapid prototyping, but rapid prototyping and rapid manufacturing(38).
SCENE 82.	NARRATION (VO): Limited material selection and available material properties is another barrier to adoption of rapid manufacturing. Although continued efforts in material development will help, the experts agree that breakthroughs will occur when industry embraces new opportunities instead of seeking direct replacements.

SCENE 83.	(BS) {1:52:59:11-1:53:25:15}Rather than trying to say rapid manufacturing needs to be able to meet this material that we've always used, and until it can replicate that material I'm not interested, instead I think people are going to start to see if I design out of the box I can do rapid manufacturing not to match what I do currently as far as materials, but instead to think completely different from that and say what kind of materials can we create using rapid manufacturing that we could not create any other way (44).
SCENE 84.	(BS) {1:56:33:19-1:56:59:01}we're using laser metal deposition techniques to create implants which have more wear resistant surfaces than typical forged or cast implants can make. So we're using some very unique material properties, where we can design in better material properties than you can make using traditional manufacturing operations, and therefore make a better end product as a result. (49)
SCENE 85. Stock footage of material testing (lab); e.g. tensile test	NARRATION (VO): However, to accommodate material properties or to design increate advanced mechanical, thermal, or electrical characteristics, the materials' performance must be known.

SCENE 86.	(CD) {2:12:17:22-2:12:23:18}But considering the material properties aren't completely defined {2:12:30:00-2:12:36:14}it makes it hard for designers to be able to make parts for the materials that are existing right now (56)
SCENE 87.	(RH) {2:06:38:21-2:06:58:17}I think it's perceived that materials and material properties are a barrier to rapid manufacturing, but the reality is that once we know what the material properties are, and once they can be made stable over a long period of time, then people can design around that (100a).
SCENE 88.	NARRATION (VO): This challenge is being addressed by SME's technical community...as is the urgent need for knowledge and education.
SCENE 89. Stock footage of college classroom or similar	NARRATION (VO): The changes that rapid manufacturing creates must be supported by new studies, sciences and learning.

SCENE 90.	(JB2) { AUDIO PROBLEM }With this technology you do need additional areas of study. We also need to go back and think about some of our original areas of study. We've come a long way, but we have a long way to go. We also need to go back and talk to our designers and professors and universities, and they need to be talking to their students about this technology and the fact that they are no longer handcuffed by what can be manufactured. (90)
SCENE 91.	Phill Dickens (PD) {Phill Dickens.mp4 21:54:55:25-21:55:18:25} The advent of rapid manufacturing will require us do work in lots of different areas of research, and also change the way we do our education. Most of the work so far is concentrated on processes and materials used in those processes. We need to do much more in the design optimization, and also the management supply chain issues. (110)
SCENE 92. Image reflection resistance to change? Maybe old time footage of assembly line	NARRATION (VO): While advancements in education, machines and materials are needed, the biggest barrier, and the one that is likely to be the most difficult to surmount, has nothing to do with technology. Instead, this barrier is within each of us.

SCENE 93.	(MS2) {1:32:29:26-1:32:37:22}Rapid technology is still very new, so for many people it's unknown, and there is a natural fear of the unknown for many people. {1:32:44:20-1:32:58:22}so in many cases designers or people who are responsible for products will be inclined to take the safe route of what's already known rather than taking the risk of doing something new, (31).
SCENE 94.	(RH) {2:07:00:29-2:07:14:27}I think that the biggest issue is going to be changing people's mindset and trying to get organizations to design in a different way and to work with these systems to give them different kinds of products. {2:07:26:21-2:07:36:27} I think organizations have vested interests and cultural barriers to change, and I think the changing management issues are the things we need to look at most.(100)
SCENE 95.	NARRATION (VO): Even in an organization that practices rapid manufacturing, changing mindsets is a challenge.

SCENE 96. Stock footage of CAD designer in action at the tube	(JB1) {1:21:45:27-1:22:09:17}Even in our shop, we've been designing and building industrial machinery since 1980, and we now have this capability and still my designers sometimes don't remember that hey, instead of building six different components I can design it into one and it can be built quite easily. That's a whole shift in paradigm of thinking that we have to overcome. (20).
SCENE 97.	NARRATION (VO): When adopted, and when the paradigm is shifted, companies will realize the greatest gains.
SCENE 98.	(ms2) {1:28:55:06-1:29:11:16}So in some cases it's a substitution, doing the same things a bit faster and a bit cheaper, but probably the most interesting applications are the technical possibilities to really do new things, create new kinds of products, new business models, new applications (26).
SCENE 99.	(JF) {1:41:11:29-1:41:37:07}Where you get the real advantage of using rapid manufacturing is if you can learn to work outside the box. If you take an existing design and manufacture it rapid manufacturing vs. traditional, there are some benefits in speed and time to market, but the big benefit is when I can take a design, optimize it for something I couldn't do before because I couldn't manufacture it, and have a better product. (36).

SCENE 100.	NARRATION (VO): Rapid manufacturing will change the way products are designed and manufactured. It will also foster new business models and practices.
SCENE 101.	(PD) {21:53:59:21-21:54:34:27}I think it will have a particular impact on the way we offshore business. There won't be the necessity to send work abroad because of the low labor costs, because there really won't be much labor involved in this type of manufacturing. The other issue that is going to occur at the same time is the rising cost of transport and emission costs through transport. So we've got these two things happening at the same time. Therefore I think we'll see much more local manufacturing due to rapid manufacturing. (109)
SCENE 102.	(RH) {2:04:22:19-2:04:34:29}elimination of tooling means you don't have to locate the manufacturing in the traditional factory locations. You can put it outside the factory, you can manufacturing on the supply chain. {2:04:42:23-2:05:00:15} I think we have a fundamental potential for changing the way we make things in the future. And I certainly think rapid manufacturing will bring back manufacturing to high wage economies such as the U.S. and Europe (97).

SCENE 103.	NARRATION (VO): Companies may also employ rapid manufacturing to create new markets and products that benefit from customization.opportunities in customized products.
SCENE 104. Simplant footage (:42) (1:49) (2:01) (2:32)	(CD) {2:13:48:16-2:14:15:00} As they start to evolve, now it opens up a whole collection of niche markets, or abilities for customized products. As these customized products start to come out, it opens the way for lower dollar investments. So as opposed to needing all the capital necessary to do the tooling to produce a product, you now can get smaller volume runs.
SCENE 105. Carry over Simplant video	(BS) {1:54:35:23-1:54:49:25}Where they can do the hundreds of thousands is if they're custom, like hundreds of thousands of hearing aids or hundreds of thousands of dental implants. All those are custom and therefore it drives it to a solution like rapid manufacturing (45).
SCENE 106.	(RH) {2:05:50:03-2:06:05:21}we see it with the Siemens and _____- and others in hearing aids. They are a perfect, small, body fitting customized part. I think we're going to increasingly see custom fitting internal and external body bits in the future (99).
SCENE 107.	NARRATION (VO): One example of customized products is in the dental field.

SCENE 108. Note: do not use Simplant video here…competitive process	(MS2) {1:33:54:14-1:34:28:10}We have a customer in Germany in the dental field that is now doing commercial series production of individualized dental restorations using our M270 system, replacing largely handwork for producing these dental bridges, which again are kind of classic suitable applications, because they are complex parts, they are small parts, and each one is individual for the patient. (32).
SCENE 109.	(MS) {1:49:21:17-1:49:29:21}It's wide open. The future is very bright for rapid manufacturing and I think more importantly is the term mass customization. (41).
SCENE 110.	{pause to set up/transition to conclusion}
SCENE 110.	NARRATION (VO): The simple concept of direct production of parts from 3D data creates new opportunities and possibilities. Eliminating constraints, rapid manufacturing will influence all aspectsevery aspect of design and manufacturing.
SCENE 111.	(RH) {2:01:59:11-2:02:08:25}I think rapid manufacturing will change manufacturing as we know it fundamentally. I think we will have profound changes in all manner of things we do (52).

SCENE 112.	NARRATION (VO): Rapid manufacturing is viable today, and it will continue to evolve over the coming years.
SCENE 113.	(GM) {2:30:58:17-2:31:27:07} We're at the very beginning of this concept of e-manufacturing or rapid manufacturing. It's real, it is beginning to happen with various select projects, but it is just touching the tip of the iceberg. As machines improve, as the processes improve, as the materials improve, and the tolerances… as the quality systems are put in place, e-manufacturing and rapid manufacturing will become more of a reality on a mainstream basis (70).
SCENE 114.	(CS) {1:15:09:10-1:15:33:12}It's incredibly cool technology, it's great technology to entice kids about manufacturing. That's one of my goals at the University of Liverpool. It still has to prove itself in terms of its cost and material properties, but I think in the next 10 years you'll se a lot of those answers solved, and they'll be solved by the young people we're training right now (14).
SCENE 115.	NARRATION (VO): With advancements in education, machines and materials, more and more companies will adopt rapid manufacturing. But, this will take time.

SCENE 116.	(MS2) {1:28:06:22-1:28:08:12}It's starting now basically. {1:28:29:28-1:28:48:22}At the moment it's the tip of the iceberg, but Wwe're seeing very rapid growth in interest, and we really expect in the next few years to be getting a foot in various different industries, and I guess for many years in the future we'll then be gradually spreading out, entering into more and more industries, more kinds of parts (25).
SCENE 117.	(CD) {2:11:54:02-2:12:10:14} I think rapid manufacturing will change manufacturing, as of today, dramatically. It will just completely overhaul it. But I think it is one of those things that will take a number of years, unfortunately (55)
SCENE 118.	NARRATION (VO): It may be years before rapid manufacturing takes hold and its impact is fully realized. Yet, there is one message that comes through loud and clear...
SCENE 119.	(JB1) {1:17:38:00-1:17:42:24}Rapid manufacturing is going to revolutionize manufacturing as we know it (15).

SCENE 120. Closing scene (CG) For additional information: SME's Direct Digital Manufacturing technical group's Web site. www.sme.org/rtam/ddm/	