



CADseek Shape Search: Benefits, Use Cases, and Return on Investment

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Abstract:

There is mounting interest in advanced search techniques to assist companies that have created hundreds of thousands and even millions of CAD designs of parts and assemblies. Unless a specific part name or number is known, the common text-based methods generally available often fail to locate the appropriate item. Shape-based search provides a solution for this problem. An effective tool of this type can quickly and accurately locate parts and assemblies using shape alone, text-based attributes alone or a combination of the two. The most common justification for employing this innovative technique for search is part reuse, which can save a company millions of dollars annually. However, there are many other reasons as well. Finding a particular part also means locating a wealth of other information associated with the part, including such things as cost, supplier names, manufacturing information and analysis results. The CAD file itself, along with all these other elements of intellectual property provide valuable documentation to support the tasks of many working at various stages of the product lifecycle.

Introduction

iSEEK Corporation is in the business of three-dimensional shape classification and search. Its flagship product, CADseek Polaris, is based on patented technology that takes the entire shape of the object or assembly into account. In a fully automated process, the CAD files of large, distributed datasets are indexed and sorted into families of similarly shaped and otherwise related designs. The results are then presented in an interactive graphical display, the Navigator, for Visual Data Management of the dataset.

There is a growing interest in shape search to enable users to locate existing designs for reuse. Certainly this goal is economically attractive, since the design and development of a new part for production can entail significant time and money. With the text-based search capabilities of today's PDM/PLM systems, the task of locating the right part in a timely manner can be daunting. Faced with aggressive program schedules and deadlines, the designer is often forced to redesign a part highly similar to ones that are already available just because there is no time to search for designs that could be reused. CADseek addresses this need by quickly and accurately locating parts and/or assemblies based on shape alone, text-based attributes alone or a combination of the two.

While design reuse is, by itself, a strong incentive to swiftly locate existing parts and assemblies, effective shape based search produces many additional advantages that enhance the work of personnel up and down the lifecycle of a product. From the earliest conceptual design to manufacture of the device to field replacement needs to recycling and reconditioning at the useful end of a product's life, shape search has a significant role to play.

Use Cases for CADseek

- **Part reuse** -- As mentioned above, part reuse is the most obvious use case for a powerful shape search product such as CADseek. To design a new part and take it through all the various stages to production costs a significant amount of time and money. When there is an existing part that can be used in the application, time and money spent on designing a new part are wasted. Being able to locate the specific part appropriate for reuse, though, is often a challenge. If the designer is faced with a deadline, and a suitable part is difficult to find, he or she will often decide to design a duplicate or highly similar part from scratch.

However, with the shape-based search capability of CADseek coupled with its

additional ability to filter results using text based attributes, finding the right part or assembly is a quick, accurate and easy task. For example, a designer working within the native CAD modeling software can send the search request to

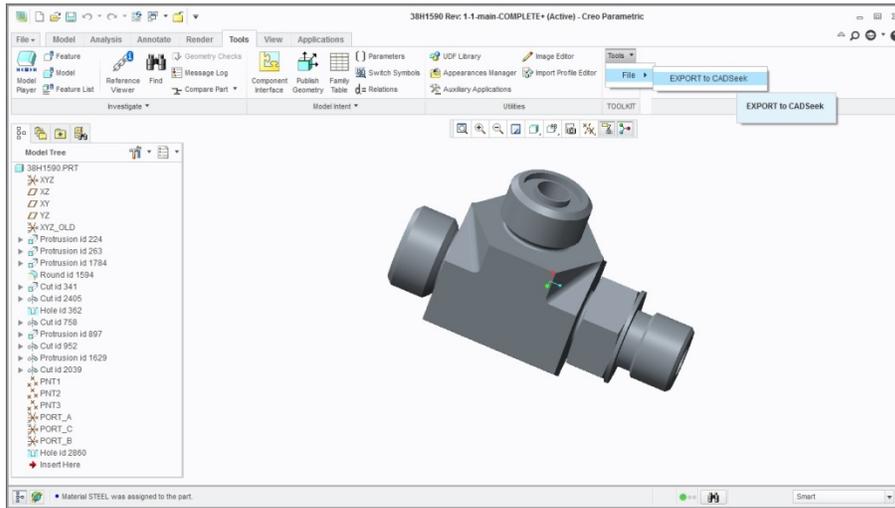


Figure 1 CADseek shape search target sent from the CAD modeling software

CADseek's shape search engine using an “Export to CADseek” option from the tools menu, Figure 1.

CADseek then provides the designer the ability to add attributes such as material, finish or supplier name before the search is performed, Figure 2.

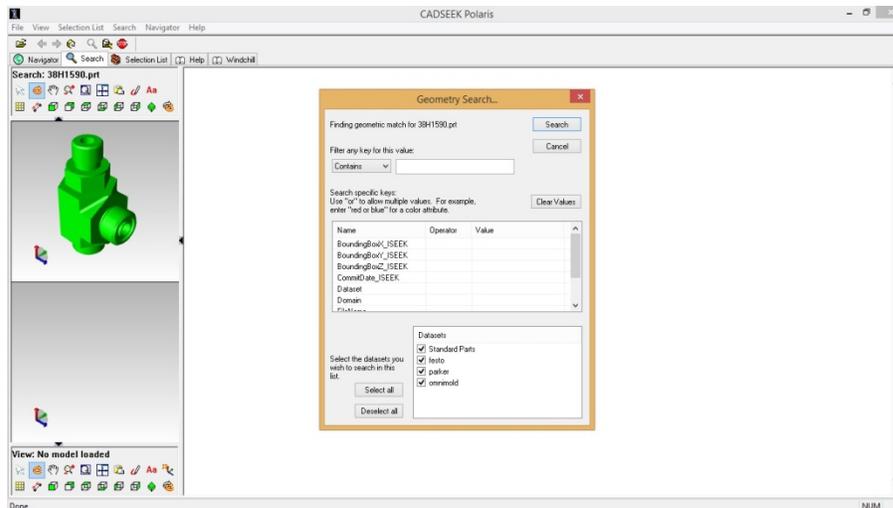


Figure 2 Attributes can be part of the search specifications in CADseek in addition to shape

CADseek returns a visual preview of the top five search results matching the search target and a count of the number of search results identified, Figure 3.

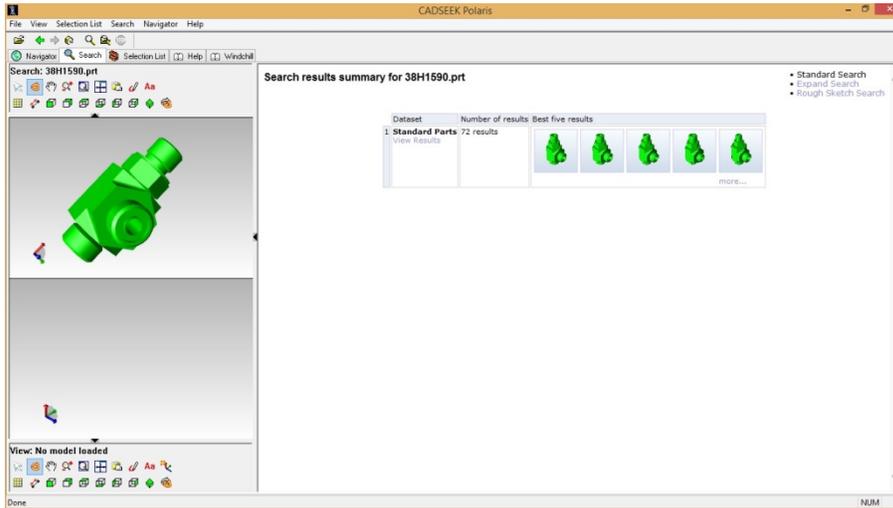


Figure 3 Preview of the top five matches

The full set of search results can then be viewed with their associated attributes as shown in Figure 4.

The savings for this one use case alone can be remarkable when considered for the aggregate results produced by multiple designers working over an extended period of time. These savings are discussed in detail later.

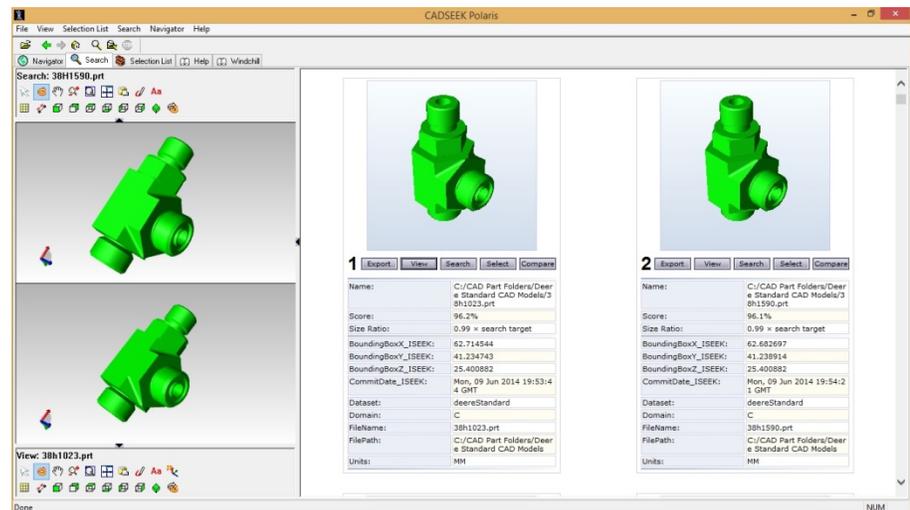


Figure 4 CADseek's detailed view of the search results

- Model reuse** – Even when it is obvious that a new part must be designed, model reuse is often useful. Some complex designs can take a week or even a month or more of intensive work with a modern CAD software package to complete. If an existing part exists that is similar in many respects to the new design, CADseek can locate that part for the designer. This significantly reduces the time to complete the



Figure 5 A complex CAD model

- **Integration of parts from company acquisitions** – A company that acquires another organization manufacturing similar products is often faced with the task of integrating the new parts and assemblies into the overall corporate database. This can be a significant challenge because the acquired company likely used a different part numbering and naming strategy, and the designs may have been created in one or more different CAD software products and stored in a different PDM/PLM system. CADseek handles all CAD formats and PDM/PLM systems without difficulty, and the numbering and naming schema are irrelevant since the basic comparison is based on the shape of the models. The resulting classification can be grouped with the existing dataset or kept separate with the ability to display and search multiple datasets in the CADseek Navigator.
- **Reuse of process plans and tooling** – If a new design is to be fabricated in house, a manufacturing engineer is generally responsible for devising a process plan to specify the various stages required to produce the end product. He or she would also need to locate any tooling and fixtures that might be available for



Figure 7 Manufacturing requires a process plan as well as specific tooling and fixtures

reuse. A quick search using CADseek will locate parts that are similar in shape and thus likely to have process plans that could be reused with or without modification for the new design. Finding tooling and/or fixtures that can be reused is an additional advantage possible from such a search.

The same would also apply to newly released assemblies that would require assembly instructions and often assembly fixtures and specifications that could be reused from other designs. Thorough consideration of the process plan and/or assembly instructions might also prompt ideas for design modifications that could simplify manufacturing and assembly of the new product.

- **Quality analysis** – In some instances a new design might be required even though there are similar shaped parts already available. A search using CADseek is still helpful from a quality standpoint. Finding similar shaped parts and/or assemblies can provide access to documents reporting any specific quality problems that were experienced with the previous designs. This will alert the appropriate personnel to establish checks and controls to reduce or eliminate any problems before they occur. In fact forehand knowledge of quality problems with other similar designs could suggest improvements in the new parts and assemblies specifically intended to eliminate problems at the outset.

- **Field service reports** – Similar to quality documentation, field service reports often describe problems with existing designs during warranty and maintenance periods of customer use. A design engineer can access such information by executing a CADseek search for new designs currently in the works. Alerted to the potential of costly recalls and field replacements, the engineer can improve the work in progress to prevent difficulties that might crop up later in the field.
- **Access to engineering analysis results** – With all of the technical based software available to design engineers today, complex designs can often be thoroughly analyzed even before prototypes are built. Software is available for such important analyses as heat transfer, computational fluid dynamics, finite element analysis and fatigue life predictions. When a designer is working on a new product that includes some elements similar to existing ones, a CADseek search can lead to a trove of valuable information regarding expected performance and suggestions for improvement of the new design. Such improvements might include better material specification and treatment, reduced weight and improved shape design for fluid dynamics flows, stress levels and fatigue life.

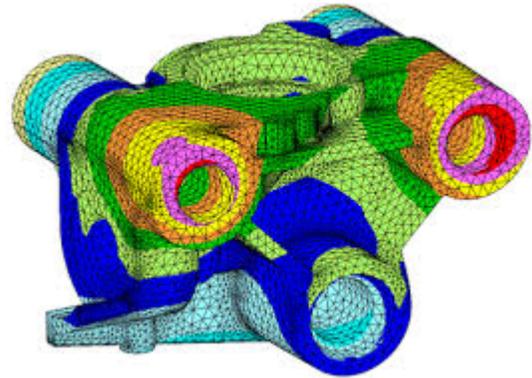


Figure 8 Finite Element Analysis results showing critical stress areas in red

- **Identification of substitute parts for production** – When a manufacturing line is shut down for any length of time, a significant cost is always incurred. If parts were not ordered in a timely manner to replenish inventory supplies, or if shipping of new parts is delayed for some reason, a shutdown might be inevitable. With CADseek, a search can often be made to identify parts that are similar enough in shape to serve as a substitute. The substitute part might be made of a more expensive material disqualifying it as a permanent replacement, but offering a very viable alternative to keep the assembly line running. Or it could be a part somewhat different in shape compared to the production part, but close enough that a supply might be reworked quickly to maintain production, eliminating a costly line shutdown.
- **Identification and qualification of suppliers** – Supply chain personnel can also benefit greatly from CADseek. They are often required to locate and evaluate potential suppliers for parts and assemblies. Once they have been assigned a

new part or assembly to be outsourced, they can quickly search the company database for similar designs. Results will provide information on which vendors likely have the capability to provide the new part and a rough estimate of cost. The purchasing agent then knows who to contact for price quotations and how to evaluate the quoted costs. Furthermore, CADseek has a very intuitive and easy to learn interface and can operate in standalone mode. Hence, supply chain personnel don't need to use CAD in order to perform a CADseek shape search.

- **Identification and location of field service parts** – Some industries have extensive field service organizations with distributors and service providers located throughout their global network. When customers need replacement



Figure 9 Scanning can produce a target image for CADseek

parts for their products, they expect to receive quick, efficient assistance. If they bring their broken or worn parts to the dealer, CADseek can provide a visual catalog of parts they can browse to search and locate the exact replacement based on the shape and textual attributes of the part. In addition, if the service provider has the ability to scan the part with a

hand-held scanner or a more sophisticated coordinate measuring machine, the digitized three-dimensional shape can be imported directly into CADseek for automated search and retrieval from the company's database.

- **Identification and location of parts for reconditioning programs** – Some companies have formal reconditioning programs that take older products, tear them down for cleaning, inspection and replacement of worn parts. Similar to use cases noted above, a worn part can be scanned to capture its shape which can then be used in CADseek to locate the part in the company's database. The replacement or a suitable substitute can then be ordered for assembly in the reconditioned device, which can then be offered for resale.

Automated Classification and the Navigator

In order to search a dataset by shape, each of the 3D models must first to be characterized numerically. CADseek does this in automated batch mode by interfacing with the PDM or PLM system or by accessing the CAD files in shared folders. Each CAD file is opened sequentially, and the entire geometry of the part or assembly is coded using CADseek's patented technology. This coding process works with any CAD format and interfaces with any of the popular PDM/PLM systems. On average a single

processor can code 25,000 parts and/or assemblies per week, but multiple processors can be utilized to reduce the overall time requirement. So, for example, if a substantial server with 16 processors is used, or if desktop units are networked to employ a total of 16 processors, 1 Million parts could be coded in 2.5 weeks. Thus, a dataset can be coded as quickly as desired by simply providing an adequate number of processors.

The end user can locate parts and assemblies using shape alone, attributes alone or a combination of the two. Attributes can be collected at the time of the shape coding or later from multiple sources. If the files are accessed by interface with a PLM system, for instance, the attributes stored there can be downloaded and stored in the thin CADseek database for search. Attributes can also be collected from CAD files themselves, from ERP systems such as SAP, from spreadsheets or other sources.

Once signature codes are established for each of the CAD files, CADseek enters a classification stage which is also fully automated. Parts and assemblies are sorted into families of similar shaped parts and assemblies as well as those that are complimentary in shape. For example, right hand and left hand designs that have the same basic shape are placed in the same family.

After classification is complete, the Navigator is populated to display billboards for each of the families. Attribute filters can also be applied to the Navigator to refine the user interface. For example, perhaps the user only wants to view parts made from a specific material or provided by a specific supplier. The Navigator can easily handle that scenario. The Navigator is then ready for efficient browsing, and individual billboards can be selected to display the individual family members along with all associated parameters.

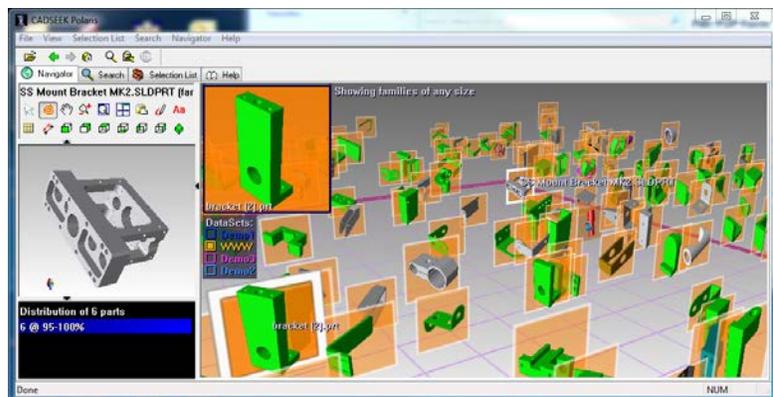


Figure 10 CADseek Navigator with family billboards

Of course, the company's CAD database will change over time with existing parts modified and new parts added. CADseek is able to maintain an accurate reflection of the latest information by dynamically coding new and modified parts when they are checked into the PDM/PLM system, and by reclassifying the entire dataset periodically. The frequency of the reclassification is up to the customer and is usually completed daily or weekly depending on how much design activity is expected.

Shape Search Using CADseek

As already mentioned, families of similar shaped parts and assemblies are displayed on billboards in the Navigator. Hence, locating a billboard with a shape of interest already provides the user with multiple parts that are very similar. However, there may be a need to look beyond the family boundaries to locate other items that are not similar enough to earn them a place in the family. This is easily accomplished by first selecting as a target a member of a family located by browsing the Navigator. Then the user launches a search in the search window, specifying one or more datasets for search along with any desired attributes. Results are returned within two seconds with JPEG images depicting parts and assemblies in descending order of similarity. Furthermore, all the stored attributes are displayed for each of the results.

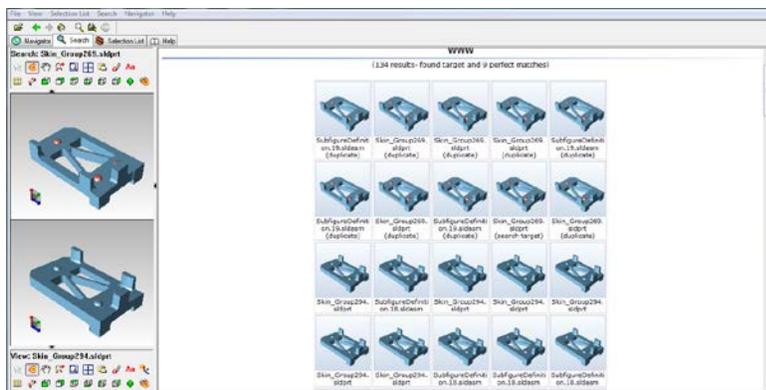


Figure 11 CADseek search results with several duplicates

There are a number of other ways to identify a target for search as well. The initial step, for example, might involve a simple text-based attribute search. The user can enter a filename or number, a key word or a specific attribute such as material, surface finish or supplier name. CADseek will then search one or more

selected datasets and return all results that satisfy the search criteria. CADseek even helps the user select appropriate values for the attributes by showing all those captured at the time of the initial coding and classification or added later to the CADseek database. Results from the text-based search might represent the final goal, or one of the parts or assemblies can then be used to initiate a secondary search on the basis of shape with the option of also adding text-based attributes.

If a user has a CAD file stored in a personal document folder, that file can also be used as a search target by simply selecting the file from within the CADseek client. CADseek first codes the shape of the part and then searches one or more selected datasets to find parts or assemblies that have similar shape. Of course, additional text based attributes can be added prior to the search if desired.

A design engineer can also transfer a file directly from a PLM system or CAD program for shape based search. A part might be fully detailed, or an incomplete design may only consist of a general shape. Either can be designated for shape search by simply selecting a CADseek entry in a pull-down menu. Once the search is complete, and the user chooses an existing part for further consideration, it can quickly be displayed in the

user's PLM or CAD package. Thus, CADseek provides for two way integration with both PLM and CAD software.

Target shapes can also be defined from assemblies displayed in CADseek's quick view window. Single parts or groups of parts can be selected by mouse click from a specific assembly and used for a subsequent shape search. The part or parts are first coded and then the search is completed without any need to specify any text information. Hence, this feature allows a user to determine the part name and associated attributes of the part as well as the identity of other parts that are similar in shape.

Finally, an actual part or assembly can be scanned with a stationary coordinate measuring machine (CMM) or hand-held device to create a point cloud representing the exterior shape. The point cloud can then be used to create an STL file or used as is for input to CADseek for shape search.

Cost of Duplication and Return on Investment – ROI

Although there are many uses for shape search, and all of them benefit the company's bottom line, the easiest to quantify is the return on investment for part reuse. A paper by the Parts Standardization and Management Committee of the U.S. Department of Defense estimates the average cost of adding a single part to a manufacturer's list of approved parts at about \$20,000. Some might disagree with this, and those in various manufacturing industries have no doubt developed their own estimates for the cost of creating a new design. It is indisputable, though, that designing and releasing a new part to production when an existing part is available for reuse introduces unnecessary and significant cost.

According to an industry estimate, engineers spend 20% of their time simply searching for information. This would include the time spent looking for a particular part that can be reused in a new application. Faced with tight schedules and difficulty finding parts using simple text-based search methods available in today's PDM/PLM systems, it's no wonder that engineers will often create duplicate or near duplicate designs to save time. A study by the Aberdeen Group quantifies this problem. "According to our research, as many as 30 to 40 percent of manufacturers' parts are duplicates or have acceptable substitutes," said Jim Brown, vice president of global Product Innovation & Engineering Research at Aberdeen Group. A shape-based search product such as CADseek can find parts and assemblies quickly and accurately to eliminate the proliferation of duplicate designs.

Consider a single engineer who creates just 20 new parts each year in addition to other responsibilities. Table 1 shows the annual cost of duplication for that engineer for

various levels of duplication and a range of estimates for duplication cost. For example, if his or her company only spends \$2,500 when creating a new design and releasing it to production, and if only one of the engineer's parts is a duplicate, then the unnecessary cost of duplication is just \$2,500. However, if the company employs 250 designers following the same profile, the annual cost is \$625,000. Or for a company that spends \$15,000 on average for each new design and has a duplication percentage of 15%, one engineer will waste \$45,000 each year for the three duplicate or near duplicate parts created. If there are 250 design engineers working for that company, they will add over \$11 Million in unnecessary spending. For a large company with 1,000 engineers, the cost balloons to \$45 Million each year.

Table 1. Annual cost for part duplication for each designer creating 20 new parts

Percent Duplication	Cost / Duplicate Part							
	\$2,500	\$5,000	\$7,500	\$10,000	\$12,500	\$15,000	\$17,500	\$20,000
5	\$2,500	\$5,000	\$7,500	\$10,000	\$12,500	\$15,000	\$17,500	\$20,000
10	\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000	\$35,000	\$40,000
15	\$7,500	\$15,000	\$22,500	\$30,000	\$37,500	\$45,000	\$52,500	\$60,000
20	\$10,000	\$20,000	\$30,000	\$40,000	\$50,000	\$60,000	\$70,000	\$80,000
25	\$12,500	\$25,000	\$37,500	\$50,000	\$62,500	\$75,000	\$87,500	\$100,000
30	\$15,000	\$30,000	\$45,000	\$60,000	\$75,000	\$90,000	\$105,000	\$120,000

Tables 2 and 3 estimate the return on investment CADseek provides by combined shape and attribute search for reuse. Calculations assume an initial CADseek investment of \$1,000 per engineer with a 20% maintenance charge for each of years two and three. For a company that spends \$2,500 for each new design and maintains a low 5%



Figure 12 CADseek produces increasing ROI

duplication level, the first year ROI is 1.5 times investment or 150%. The entire investment would be repaid in less than six months. Over the first 3 years the ROI for this example increases to 4.4 times the investment as shown in Table 3.

For the second example described in the previous paragraph, where the duplication level is 15%, and the cost for each new part is \$15,000, the first year ROI is 44.0 times the investment. Over a span of three years, such a company with 1,000 designers will have spent \$135 Million (3 x 1,000 x \$45,000) creating duplicate or very similar parts. The total investment to prevent that waste would be just \$1.4 Million (1,000 x \$1,400). Hence the three year ROI would be 95.4 time the investment as shown in Table 3

Table 2. First year ROI for an initial investment of \$1,000/designer creating 20 new parts

Percent Duplication	Cost / Duplicate Part							
	\$2,500	\$5,000	\$7,500	\$10,000	\$12,500	\$15,000	\$17,500	\$20,000
5	1.5	4.0	6.5	9.0	11.5	14.0	16.5	19.0
10	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0
15	6.5	14.0	21.5	29.0	36.5	44.0	51.5	59.0
20	9.0	19.0	29.0	39.0	49.0	59.0	69.0	79.0
25	11.5	24.0	36.5	49.0	61.5	74.0	86.5	99.0
30	14.0	29.0	44.0	59.0	74.0	89.0	104.0	119.0

As mentioned earlier, the multiple use cases described for CADseek all produce significant advantages that impact the corporate bottom line. Combined with the results demonstrated here for design reuse alone, the expected opportunity for maximizing a company's profit is truly impressive.

Table 3. ROI over three years for a total investment of \$1,400/designer based on 20 new parts/year

Percent Duplication	Cost / Duplicate Part							
	\$2,500	\$5,000	\$7,500	\$10,000	\$12,500	\$15,000	\$17,500	\$20,000
5	4.4	9.7	15.1	20.4	25.8	31.1	36.5	41.9
10	9.7	20.4	31.1	41.9	52.6	63.3	74.0	84.7
15	15.1	31.1	47.2	63.3	79.4	95.4	111.5	127.6
20	20.4	41.9	63.3	84.7	106.1	127.6	149.0	170.4
25	25.8	52.6	79.4	106.1	132.9	159.7	186.5	213.3
30	31.1	63.3	95.4	127.6	159.7	191.9	224.0	256.1

Furthermore, if a company has a large number of duplicate or highly similar parts, they are forfeiting unnecessary inventory carrying costs from tracking, ordering and stocking many more parts than needed. In addition, if they are ordering several duplicate parts under different part numbers or names, they will undoubtedly pay more than if they would order larger quantities of a single part offered at a lower piece price.

Conclusion

CADseek provides multiple uses beneficial to any mid to large sized company that manufactures products consisting of parts and assemblies. From the basic need to locate parts for reuse to identification of all the metadata and associated documentation of past designs in the distributed corporate database, CADseek provides the key to efficient utilization of the company's intellectual property.

The savings from part reuse alone will provide an immense cost benefit to a company, and the additional use cases add significantly to the overall advantage provided by CADseek. The ability to classify and search for parts and assemblies based on shape alone, attributes alone or a combination of the two regardless of the initial CAD format involved or the PDM/PLM system or other repositories housing the data adds extreme versatility to the software. Thus, CADseek enhances a company's effort to bring designs to the market faster than ever, provides unparalleled value to the customer and maximizes profits for the enterprise.

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