Benchmarking in the South
African Tool and Die Manufacturing Industry

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Thesis presented in partial fulfilment of the requirements for the degree of Masters of Industrial Engineering at Stellenbosch University.

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March 2007
I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not, in its entirety or in part, submitted this work at any university for a degree.

Ek, die ondergetekende verklaar hiermee dat die werk gedoen in hierdie tesis my eie oorspronklike werk is wat nog nie voorheen gedeeltelik of volledig by enige universiteit vir 'n graad aangebied is nie.
The trouble with the light of learning is that we can end up believing both the world and ourselves to be already charted when in fact we have been blinded by the light source itself, with the result that our surroundings seem dark and unfathomable while our own noses are brilliantly illuminated. Anyone who travels through Africa in a brightly lit railway carriage is bound, on his return home, to tell everyone that Africa is a lowering forest fringe.

*Peter Høeg – Tales of the Night: Journey into a Dark Heart*
The supply of manufactured products depends on tool, die and mould (TDM) manufacturing. The TDM industry provides the machines, tools and equipment necessary to produce most manufactured components. The TDM industry is a high value-adding constituent in the supply of manufactured products by being at the heart of component manufacturing and by forming the backbone of the manufacturing sector. Unfortunately, the South African TDM industry experienced a steady economic decline during the last decade. This decline resulted in a negative effect on the domestic manufacturing industry. The South African government realised the evident need to restructure and develop the TDM industry. This research forms part of government incentives to increase global competitiveness of the South African TDM industry.

The South African TDM industry lacks the capacity to supply in the local demand. This study determines shortfalls and the need for improvement by comparing the South African industry against its global counterparts. A benchmarking methodology is developed to identify improvement plans for individual tool rooms and for the industry as a whole. Recommendations for the domestic industry are provided through conclusions drawn from the study.

The benchmarking methodology can be applied to an industry or to an individual concern. A pilot implementation of the methodology was performed in three specific tool rooms. This thesis analyses the South African TDM industry in its entirety and provides recommendations to improve competitiveness.

A database is populated with tool room-specific information. The information is manipulated into performance indicators (PI) for comparison. The benchmarking methodology allows for a subset (of one PI) to be averaged and compared against the entire dataset or some other subset. PIs of South African tool rooms (subset 1) are compared against the PIs of global counterparts (subset 2). This benchmark allowed identification of trends and areas for improvement.

The analysis is based on a hypothesis pertaining to the current competitiveness of the industry. The hypothesis stems from the averaged productivity and turnover PIs of the
industry under consideration. The hypothesis can originate from the comparison of the productivity and turnover PIs of a single tool room and the industry average in the event of a performance analysis for a single tool room.

This thesis postulates that the South African industry is not globally competitive. Support for the hypothesis is gained by grouping all PIs into core statements, where each core statement addresses a specific area of influence. The core statements are analysed in a framework of five identified success factors. Performance in the success factors supports the stated hypothesis and provides information with regard to specific areas of competitive and non-competitive performance. Recommendations to improve competitiveness are based on this analysis methodology.
OPSOMMING

Die verskaffing van vervaardigde produkte is afhanklik van die vervaardiging van werktuie, stempels en vorms (WSV). Die WSV-bedryf verskaf die masjinerie, gereedskap en toerusting wat nodig is vir die produksie van die meeste vervaardigde komponente. Die WSV-bedryf is ’n belangrike waardetoëvoegende bestanddeel in die verskaffing van vervaardigde produkte aangesien dit die kern van komponentvervaardiging en die ruggraat van die vervaardigingsektor uitmaak.

Ongelukkig het die Suid-Afrikaanse WSV-bedryf die afgelope dekade ’n bestendige ekonomiese afname beleef. Hierdie afname het ’n negatiewe uitwerking op die binnelandse vervaardigingsbedryf in Suid-Afrika tot gevolg gehad. Die Suid-Afrikaanse regering het die ooglopende behoefte aan herstrukturering en ontwikkeling van die WSV-bedryf raak gesien. Hierdie navorsing maak deel uit van die regering se aansporings om globale wedywering van die Suid-Afrikaanse WSV-bedryf te verbeter.

Die Suid-Afrikaanse WSV-bedryf beskik nie oor voldoende kapasiteit om in die plaaslike vraag te voorsien nie. Hierdie studie bepaal tekortkominge en die behoefte aan verbetering deur ’n vergelyking van die Suid-Afrikaanse bedryf met wêreldwyse opposisie. ’n Normstellende metodologie word ontwikkel vir die identifisering van verbeteringsplanne vir individuele gereedskapkamers en vir die bedryf as ’n geheel. Aanbevelings vir die binnelandse bedryf word voorgestel na aanleiding van gevolgtrekkings wat op grond van die studie gemaak word.

Die normstellende metodologie kan toegepas word op ’n bedryf of op ’n individuele onderneming. ’n Proefimplementering van die metodologie is in drie spesifieke gereedskapkamers uitgevoer. Hierdie tesis ontleed die Suid-Afrikaanse WSV-bedryf in sy geheel en maak aanbevelings vir die verbetering van mededingendheid.

’n Databasis word gelaai met inligting wat op ’n gereedskapkamer in die besonder van toepassing is. Die inligting word in prestasieaanduiders (PI’s) gemanipuleer met die oog op vergelyking. Die vergelyking maak daarvoor voorsiening dat die gemiddeld van ’n ondergroep (van een PI) bereken kan word en met die volledige datastel of een of ander dergelijke ondergroep vergelyk kan word. PI’s van Suid-Afrikaanse gereedskapkamers (ondergroep 1) word vergelyk met die PI’s van konkurrente van regoor die wêreld...
 OPSOMMING

(ondergroep 2). Die vergelyking maak voorsiening vir die identifisering van tendense en areas vir verbetering.

Die ontleiding is gebaseer op 'n hipotese wat verband hou met die huidige mededingendheid van 'n bedryf. Die hipotese spruit voort uit die gemiddelde produktiwiteit en omset PI's van die bedryf soos dit hier bespreek word. Die hipotese kan ontstaan vanuit die vergelyking van die produktiwiteit en omset KPI's van 'n enkele gereedskapkamer en die gemiddeld van die bedryf in die geval van 'n prestasieontleding vir 'n enkele gereedskapkamer.

Hierdie tesis postuleer dat die Suid-Afrikaanse bedryf nie op wêreldvlak mededingend is nie. Ondersteuning vir die hipotese word verkry uit groepering van al die PI's in kernstellings, waar elke kernstelling op 'n besondere belangstellingsarea toegespits is. Die kernstellings word ontleed in 'n raamwerk van vyf geïdentificeerde suksesfaktore. Prestasie in die suksesfaktore ondersteun die hipotese soos gestel en verskaf inligting met betrekking tot besondere areas van swak of mededingende prestasie. Aanbevelings vir die verbetering van mededingendheid is op hierdie ontledingsmetodologie gebaseer.
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Mr K von Leipzig, Department of Industrial Engineering at the Stellenbosch University, for his input in adapting the original benchmarking model into the South African industrial environment.

Mr C Jooste, at the Automotive Industry Development Centre, for initiating the project and coordinating the participation of the tool rooms.

The South African Department of Trade and Industry and the Automotive Industry Development Centre (AIDC), for the necessary funding to implement the developed benchmarking methodology in three identified tool rooms. The identity of the tool rooms are kept confidential throughout this document. The confidentiality is in line with the contractual agreement between AIDC and the tool rooms.

National Research Foundation of South Africa & KFZ Jülich in Germany for funding the collaboration between GCC and WZL in a research effort to improve the South African tool and die manufacturing industry.

The participating tool rooms for their engagement and cooperation, which enabled us to complete the project successfully.
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# GLOSSARY

## Acronyms

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<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>AIDC</td>
<td>Automotive Industry Development Centre</td>
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<tr>
<td>ASGISA</td>
<td>Accelerated and Shared Growth Initiative for South Africa</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<tr>
<td>CNC</td>
<td>Computer Numerical Control</td>
</tr>
<tr>
<td>CS#</td>
<td>Core statement, where # depicts the number of the core statement</td>
</tr>
<tr>
<td>DCQ</td>
<td>Data capturing questionnaire</td>
</tr>
<tr>
<td>DTI</td>
<td>Department of Trade and Industry</td>
</tr>
<tr>
<td>EDM</td>
<td>Electrical discharge machining</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FRIDGE</td>
<td>Fund for Research into Industrial Development, Growth and Equity</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>HSC</td>
<td>High Speed Cutting</td>
</tr>
<tr>
<td>I</td>
<td>International</td>
</tr>
<tr>
<td>ISIR</td>
<td>Initial Sample Inspection Report</td>
</tr>
<tr>
<td>ISTMA</td>
<td>International Special Tooling and Machining Association</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicators</td>
</tr>
<tr>
<td>MIDP</td>
<td>Motor Industry Development Programme</td>
</tr>
<tr>
<td>MS</td>
<td>Microsoft Office</td>
</tr>
<tr>
<td>NAACAM</td>
<td>National Association of Automotive Component and Allied Manufacturers</td>
</tr>
<tr>
<td>NAAMSA</td>
<td>National Association of Automobile Manufacturers of South Africa</td>
</tr>
<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
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<tr>
<td>PI</td>
<td>Performance Indicator</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>RFQ</td>
<td>Request for quotation</td>
</tr>
<tr>
<td>SA</td>
<td>South Africa</td>
</tr>
<tr>
<td>SATISI</td>
<td>South African Tooling Industry Support Initiative</td>
</tr>
<tr>
<td>SMMEs</td>
<td>Small, Medium and Micro Enterprises</td>
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<tr>
<td>TASA</td>
<td>Tooling Association of South Africa</td>
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Benchmarking

**Benchmarking** is the sharing of strategic business knowledge through comparative studies of business processes with the aspiration to generate new and beneficial knowledge through long-term symbiotic participation.

**Benchmarking Exercise**

This refers to Benchmarking of tool rooms according to the explained **benchmarking model**. The purpose of a **benchmarking exercise** is to determine strengths, weaknesses and general trends for each **participating tool room** and for the South African industry as a whole.

**Benchmarking Indicators**

104 Indicators are calculated by the **benchmarking model** (BM) from the information captured through the **data-capturing questionnaire** (DCQ). A tool room can measure its own performance through comparing an indicator against the minimum, average and maximum values of the dataset through which an understanding of **success factors**, shortcomings and trends can be developed. Indicators are grouped into **core statements** according to their similarities, for interpretation and analysis.

**Benchmarking Model**

**Benchmarking model** refers to the data capturing and analyses software application. The application is a Microsoft Excel file coded in Visual Basic for Excel. The application captures information from a **data-Capturing questionnaire** and calculates **benchmarking indicators** as output. The benchmarking output depicts the information through graphical representations, referred to as **output graphs** for further analysis.

**Core Statements**

The **benchmarking model** presents indicators for comparison in **21 core statements**. Specific indicators, relating similar information, are grouped for interpretation and
The significance of the **21 core statements** about the competitiveness of a tool room are presented in this report.

**Data-capturing questionnaire**

The **data-capturing questionnaire** is a Microsoft Excel file that captures a tool room’s information for the benchmarking exercise. The tool room completes this questionnaire for the calculation of **benchmarking indicators** through the **benchmarking model**.

**General Benchmarking Procedure**

The **general benchmarking procedure** describes the **benchmarking model** and the **analysis procedure** in order to conduct a benchmarking study. Analysis of such a study, based on information obtained through the **general benchmarking procedure** can be conducted for a specific tool room or an industry as a whole.

**Key Performance Indicators**

The **key performance indicators** are the performance indicators from which the performance of a tool room in the five success factors is hypothesized.

**Output Graphs**

The **output graphs** are the graphical display of the **benchmarking indicators**, and are fully explained in the **general benchmarking procedure** (Paragraph 3.2.3 of this report).

**Participating tool rooms**

This refers to the three South African tool rooms that participated in a **benchmarking exercise** during 2005. The study determined strengths, weaknesses and general trends for each tool room and for the South African industry as a whole.

**Process Chain**

The process of manufacturing a tool, die or mould. This chain consists out of a **planning phase** and an **execution (realisation) phase**:

**Planning Phase:**

The **planning phase** consists of three processes:
1. **Die Concept and Design**

The phase in which die concept is generated and design of the concept is done.

2. **Process Planning**

Planning the manufacturing process, allocating resources e.g. scheduling time and determining costs to produce a tool, die or mould according to specifications, either generated in the die concept and design phase or as required by the client.

3. **NC Programming**

Programming of the NC machines takes place in this phase.

**Execution (Realisation) Phase**

The execution (realisation) phase consists of three processes:

1. **Metal-cutting**

Metal-cutting of components to produce a tool, die or mould takes place during this phase.

2. **Finishing and Final Assembly**

The finishing of components (e.g. polishing) and the assembly are done during this phase.

3. **First-off Tool Trail Runs**

This is the first trail run for the tool to determine if there are any flaws and the rectification of the flaws.

**Performance Indicators**

The performance indicators (PIs) depict the performance of a tool room through information presented as ratios of data obtained by the data capturing questionnaire. The indicators can be grouped and compared to conduct analysis of the performance of a tool room.

**Project Managers / Cost Estimators**

Skilled personnel in planning the time and cost schedule for the production of a tool or die.
**Success Factors**

**Success factors** are identified areas in which a tool room must excel to achieve global competitiveness. The five areas identified for the South African industry are:

1. **Focus Ability**

The ability of a tool room to focus on core competencies and manufacturing requirements concerning:

- a specific industry, or industries, to have an experience advantage and a niche in the market
- production technologies and methods, to increase efficiency through outsourcing all non-core production capabilities

Collaboration in the industry will be advantageous to the focus ability of tool rooms in South Africa.

2. **Technology Base**

The technology base refers to the level of modern technologies utilized by the tool room. A tool room’s investment strategy has a direct influence to its technology base. The current and desired production capabilities of a tool room will influence the investment strategies to advance the technology base according to the focus ability of a tool room.

3. **Skills**

This is the level of experience and expertise of the personnel in a tool room. Specific skills need to correspond with the focus ability and technology base of a tool room.

4. **Efficiency**

Efficiency is the cost of input to the value of output for manufacturing a tool or die. Efficient utilisation of resources within a tool room, such as personnel skills, technologies and materials, are necessary to achieve competitive levels in tool production. Resource utilisation to transform raw materials into competitive tools in a timely fashion within customer expectations at a competitive price is measured by efficiency.
5. Motivation

Motivation is the satisfaction of employees within their work environment. Motivated personnel are essential to achieve competitive production.

Tool Designers / Engineers
Tool designers and engineers are the personnel with knowledge of design requirements and production techniques. The tool designing and engineering skills in a tool room transform the die concept into a detailed design and a work breakdown structure.

Tool Makers
Personnel experienced in making and repairing tools and parts.

Tool Room
An organization manufacturing tools, dies and moulds.

Analysis Procedure

Analysis Procedure refers to the benchmarking procedure for analyzing a tool room’s competitiveness. The procedure compares key performance indicators to determine the competitiveness of a tool room. The analysis procedure consists of the following steps:

1. Hypothesis statement
A tentative supposition concerning the competitiveness of a tool room is stated. The basis for the hypothesis is the tool room’s productivity per employee and turnover per employee key performance indicators.

2. Investigation through Benchmarking
Support for the hypothesis is through investigation of the tool room’s performance in the success factors. Core statements group the 104 performance indicators into 21 areas of significance. Each core statement presents information concerning a performance sphere of activity. The performance in the success factors can be determined by grouping core statements relevant to each success factor. A comparative study between industry performance and the tool room’s performance in each success factor motivates the competitive performance as postulated in the hypothesis statement.
3. Recommendation through Gap Analysis

The above investigation shows the competitive performance in each success factor of a tool room. The benchmarking model depicts the performance of the industry and shows the current capabilities of the tool room under investigation. This information allows the tool room to determine its performance expectations to achieve global competitiveness. The variance between the current performance and the desired performance becomes the gap analysis. Benchmarking allows for identification and development of recommendations to bridge the gap.
1. **INTRODUCTION**

1.1 **Background Information**

The South African tool, die and mould (TDM) manufacturing industry has experienced a steady economic decline and lost significant ground in its global competitiveness during the last decade. Trade barriers in the global manufacturing environment reduced rapidly over the last 20 years. This leaves no room for inefficient manufacturers to hide [Morris, Bessant, Kaplinsky & Barnes, 2003:2].

Competitive tooling imports forced the South African TDM industry to cut costs, which the industry did mainly by reducing expenditure in personnel training combined with declining investments in newer technologies. These cost-cutting measures diminished the industry’s global competitiveness.

In 2003, the Growth and Development Target Investigation cited that 33 000 apprentice artisans had been registered in 1975, 12 000 in 1982, and this then rapidly reduced to a mere 3 000 in 2001. In 2003, there were only 1 440 registered engineering learnerships [Hopkins, 2003]. Furthermore, Con Fauconnier, outgoing president of the Chamber of Mines stated in an article under the title “Artisan Alert” in *Engineering News*, dated 16 December 2005, that the average age of South African artisans has increased to an estimated 54 years. The low number of toolmakers in South Africa, only 499 registered [Cromberge, 2005:16], is reflected through these statistics and is very perturbing for the sustainability of the South African TDM industry.

A study conducted by the Fund for Research into Industrial Development, Growth and Equity (FRIDGE) states, “The average level of investment annually by local TDMs over the past 5 years has been R1 million … and … The current investment levels are considered low by international standards. Investment of approximately R15 million per tool room is required to bring the industry to internationally competitive standards with a further annual investment of 10% to 15% of turnover to maintain competitiveness” [FRIDGE, 2005:73]. The low investment levels are reflected in the high average age of equipment, 10 to 15 years according to the latest figures by the Tooling Association of Southern Africa (TASA).
Tooling demand in South Africa increased significantly during the same period. Total demand was valued at R3.3 billion in 2004. Packaging and automotive tooling claims 90% of this demand [FRIDGE, 2005:9]. The South African government introduced the Motor Industry Development Programme (MIDP) on 1 September 1995. The result of the MIDP is a healthy economic growth rate in domestic automotive manufacturing with a significant increase in the demand of automotive TDM products. Unfortunately, the local TDM industry is not positioned to benefit from this growing market. Tooling imports by the South African automotive industry reached a value of R6.35 billion between 2001 and 2005, according to the Department of Trade and Industry (DTI) trade statistics [DTI, 2006]. The weak capacity of the domestic TDM industry to supply for the growing automotive market consequently resulted in a trade deficit of R4.6 billion [DTI, 2006]. These perturbing trade statistics heighten the concern in the poor competitiveness of the domestic TDM industry.

The DTI realised the need for restructuring of the TDM industry to increase its global competitiveness. A comparative study between the South African TDM Industry and its international counterparts was proposed. This report analyses the South African TDM Industry through a competitive benchmarking study between the domestic and international tooling industries. Twelve domestic and approximately 50 international tool rooms provided information from which Performance Indicators (PIs) were determined. A comparison of the PIs between the domestic and international tool rooms allowed for the identification of strengths and weaknesses in the domestic industry. Identified problem areas are addressed through action plans to achieve global competitiveness in the South African TDM industry.

1.2 Significance of the Research

This study identifies opportunities in the South African TDM industry. It is in line with national government incentives to accelerate economic growth. Application of the benchmarking methodology determines the actual performance of the domestic TDM industry as compared against the global TDM industry performance. The South African government recognises the importance of the revival of South Africa’s TDM industry. There are two reasons for this new interest in the industry:

Firstly, 90% of the South African tooling industry comprises small, medium or micro enterprises (SMMEs) [FRIDGE, 2005:9]. SMMEs are the economic backbone of
developing economies and account for approximately 60% of all employment in South Africa, with a contribution of 40% to the South Africa’s gross domestic product (GDP) [CSIR, 2001]. In addition, SMMEs are often the vehicle by which entrepreneurs from all socio-economic levels gain access to economic opportunities [CSIR, 2001].

Secondly, the value adding of tooling in the economy is extremely high. When material purchased, conversion rates, turnover levels and supply prices to the industry are taken into consideration, the value-added factor for tooling is estimated at 1:19. This equates to a 19-fold increase in economic value of the cost input to producing a tool, die or mould [FRIDGE, 2005:73]. The economic benefit of component manufacturing, using tools and dies, is as significant. For every R1 million invested in TDM equipment and technology, over R250 million of components could be manufactured, making the industry an important value-added catalyst in the South African economy [FRIDGE, 2005:9].

Development of the small enterprise sector is crucial, especially the TDM industry with its high value-adding benefits, if the South African government’s target of a 6% per annum sustainable economic growth rate is to be achieved. This desired economic growth is to be achieved by 2014, as expected of the task group of Vice-President, Ms Phumzile Mlambo-Ngcuka [ASGISA, 2005:6].

Yet, Government and the industry have done very little research so far to develop improvement plans for the South African TDM industry. Competitive comparisons between the domestic and global TDM industries can improve the effect of government intervention. Development of successful improvement strategies needs to incorporate global trends and domestic shortfalls. A model to understand the current state of South Africa’s TDM industry, as compared to global competition, and a systematic approach to determine key areas for improvement are essential in any strategy to raise the industry’s competitiveness.

Competitive benchmarking provides a way to determine factors for the success of an organisation or industry. By systematically comparing and analysing PIs, strengths and weaknesses can be identified as well as general trends and success factors [Bilsing & Klocke, 2004:323]. This report determines general trends in the South African TDM industry. A pilot implementation of the methodology was conducted in three selected tool rooms. The implementation in one tool room is presented as a case study in Appendix D.
of this report. The participating tool rooms are compared against the local and international TDM industries to determine their performance. The current study uses this initial implementation to develop recommendations for strategic intervention to improve the domestic TDMs competitiveness.

The pilot implementation demonstrates the value of benchmarking for individual concerns, while at the same time, information is gathered to determine key areas for Government and private sector intervention. Participating tool rooms benefit by obtaining a better understanding of their own performance in terms of development of personal improvement strategies. The accumulated information and analysis thereof allow identification of problems from which industry-wide improvement strategies can be developed and implemented.

### 1.3 Problem Statement and Objectives of the Research

The South African tooling industry is currently working significantly below capacity and equipment is aging. The automotive industry alone experienced a domestic trade deficit of R5.69 billion, accumulated during 2002 through to November 2006 [DTI, 2007], as stated earlier. The diagram below portrays the trade deficit experienced in automotive tooling acquisition.

![Trade in South African Automotive Tooling](image)

*Figure 1-1 Trade in South African Automotive Tooling*

SOURCE: Department of Trade and Industry Trade Statistics [DTI, 2007]
Research conducted to assess the nature of the TDM industry, claims that the South African TDM industry is not currently well positioned to take advantage of the growth opportunities available to it but that it has the possibility of adapting efficiently and effectively [FRIDGE, 2005:5]. The high value of imported tools, dies and moulds confirms the lack of global competitiveness in the domestic TDM industry. Restructuring through dedicated action plans is essential for the survival of South Africa’s TDM industry.

Benchmarking of the South African tool, die and mould manufacturing industry may offer a clear understanding of specific problems, shortcomings and potential advantages in the industry. Competitive benchmarking allows for the development of analyses and recommendations of required changes through a restructuring action plan for the domestic industry. This thesis proposes the necessary strategic changes, based on a benchmarking study, on an industry-wide level and discusses improvement plans through clustering, government intervention and long-term strategic financing.

This thesis postulates the following:

- the TDM industry is not currently positioned to take advantage of the outstanding growth in the automotive industry and the general economic growth in the rest of the domestic economy; and
- the South African TDM industry can position itself during the next ten years to take advantage of the economic growth experienced in the South African economy.

The objectives of this study comprise the following:

1. to adapt a previously developed benchmarking model for the tooling industry in order to conduct a pilot implementation in three identified tool rooms (also referred to as participating tool rooms);
2. to develop an analysis methodology in order to identify improvement areas and to establish recommendations for the participating tool rooms;
3. to develop a generic documentation structure of the analysed information in order to provide the participating tool rooms with a working document that would serve as guidance for the implementation of improvement strategies; and
4. to show that the methodology can be applied to the industry as a whole for the development of macro-economic intervention strategies.
This study does not aim to provide advanced research on benchmarking as a business management tool, but is rather focused on the application of competitive benchmarking in the tooling industry of South Africa.

1.4 Methodology and Structure of the Report

Economic problems are imminent in the domestic TDM industry, unless the industry restructures itself to be globally competitive, as shown in the previous sections. A foundation for the significance of the research was provided and the problem statement was formulated with a clear description of the objectives to be achieved.

The following chapter comprises a literature study to assist the research by providing an overview of global and domestic trends in the tool, die and mould manufacturing industry. The chapter therefore offers an understanding of the influence global trends have on the domestic industry. Chapter 2 presents the success factors for TDM manufacturing on which most of the analysis for this thesis rely.

Chapter 3 forms the basis of the benchmarking methodology. The first section of the chapter explains the benchmarking model, as developed in order to observe and interpret the position of the domestic TDM industry and to conduct tool room-specific benchmarks. The second section of Chapter 3 presents the source of the available information and the data-capturing methodology for new information in the benchmarking database. Information in the database allows for analysis and interpretation. The chapter concludes with an analysis procedure (AP), developed as part of this thesis, for analysing individual concerns and the domestic industry as a whole.

The fourth chapter briefly discusses the application of the benchmarking exercise in the South African TDM industry. The chapter further provides an understanding and analysis of the South African industry, drawn from the benchmarking study. A full report on one of the three selected tool rooms is provided in Appendix D.

The final chapter, Chapter 5, provides improvement strategies and measures for the TDM industry and recommendations for future research. This thesis recommends strategic intervention through a macro-economic model in order to address the problems as identified in Chapter 4, the formation of tool room clusters and long-term financial support through government incentives. The benchmarking methodology could monitor
and manage the proposed strategies on an industry-wide level. This will allow the full potential of benchmarking to contribute to the growth and development of the industry through continuous application of the methodology.

Chapter 5 concludes with an overview of the most important claims in this thesis and future endeavours to enhance competitiveness of the domestic TDM industry. Figure 1-2 summarises the logical structure of this document.
2. STATE OF THE TDM INDUSTRY

2.1 Trends in the Global TDM Industry

Market-driven economies demand the manufacturing of a diverse range of products. Skills and innovation are required with the introduction of every new product for the manufacturing of production tools, dies and moulds. These demands necessitate continuous improvement of production methods, technologies and skills in global tool and die industries.

The global TDM industry was officially valued at US$22 billion in 2004 [FRIDGE, 2005:6]. This estimate is probably below the true value due to insufficient capturing of informal manufacturing by micro-enterprises. The TDM industry consists of 80% small to medium-sized enterprises [FRIDGE, 2005:6].

Independent tool making developed because of larger companies selling off or closing their tool-making activities in pursuit of lower costs and the fashion to reduce “indirect labour”. A strive for higher efficiencies resulted in many casualties of tool rooms. The FRIDGE study notes two principle reasons for this [FRIDGE, 2005:16]:

Firstly, competitive tender is the main consideration for the commissioning of tool-manufacturing contracts, so margins are usually very tight. Cost estimators need to determine the tool-making process accurately, while toolmakers need to realise the process. Mistakes in tool making are very expensive. The high financial investment in one commission for a small tool room can destroy the company in the event of a manufacturing mistake.

Payment terms and cash flow comprise the second principle reason for failure. While long lead times with high costs involved are customary in TDM manufacturing, cash shortages can be extremely problematic for a TDM manufacturer. Traditional payment terms in the USA are typically 30% with order placement, 30% when half complete, 30% on delivery of Initial Sample Inspection Report (ISIR) and 10% on commissioning. The bulk of cost allocation is early in the tool-making process with the acquisition of blocked-up components, development of die concept and design and numerically controlled (NC) programming of the cutter-paths for NC machining. With lead times for tool
manufacturing of up to 26 weeks, cash flow can become very problematic. Cash flow can even become fatal with customer design changes during the tool-making process. The high financial risk associated with tool manufacturing prevents Western banks to lend money or provide overdraft facilities for tool rooms.

Reduction in the need for manual labour skills through continuous investment in modern technologies of the Pacific Rim countries and some Western European countries (Portugal, Italy and Spain, for instance) provide strong competition for tool rooms. Labour cost in Western tool rooms reached 50% of total costs incurred in the late 1990s because of the very high salaries for skilled workers [FRIDGE, 2005:17]. Competition increased significantly with choice in tool supply swinging more towards best price and short lead times.

The FRIDGE study of June 2005 cited, with the International Special Tooling and Machining Association (ISTMA) as source, found that the average cost of personnel as percentage of turnover in the global TDM industry is 40.3% [FRIDGE, 2005:20]. The same study found that relaxed labour regulations in developing economies have above average working hours when compared to economies with rigorous regulations. Actual hours worked in Korea and Malaysia during 2003 was 130% of normal working hours per annum [FRIDGE 2005:6]. Normal working hours are defined as a 45-hour working week according to the South African Basic Conditions of Employment Act [South African Labour Guide, 2007]. Countries with high labour costs, especially in the European Union (EU), find it difficult to compete against the lower labour costs of emerging manufacturing economies. Ventures to compete against low-cost manufacturing economies include excellent manufacturing techniques and collaboration in the value chain. Production knowledge, with more modern manufacturing techniques, is applied in order to service customer needs with higher quality products. The facilitation of long-term partnerships between tool suppliers and clients is encouraged to increase competitiveness through more product knowledge through the supply chain.

As opposed to the high costs of developed countries, low-cost developing economies are providing low-cost tools in a timely manner, thereby creating potential for investment in technologies for the production of more complex higher value-adding tools. Developing economies, especially Asian economies, will explore the market for complex high value adding tools increasingly in the near future.
2.2 Trends in the South African TDM Industry

TDMs in South Africa are small enterprises as shown in Table 1 below. Tool rooms in the four South African provinces with the strongest industrial contribution to the South African GDP provided information a number of companies within each province and the number of employees per company. The number of employees is grouped for micro, very small, small, medium and large companies, as shown in the table below.

Table 2-1 TDM firm size and distribution

<table>
<thead>
<tr>
<th>NUMBER OF COMPANIES</th>
<th>NUMBER OF EMPLOYEES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 to 5</td>
</tr>
<tr>
<td>Micro</td>
<td>Very small</td>
</tr>
<tr>
<td>Gauteng</td>
<td>20</td>
</tr>
<tr>
<td>KwaZulu-Natal</td>
<td>10</td>
</tr>
<tr>
<td>Eastern Cape</td>
<td>8</td>
</tr>
<tr>
<td>Western Cape</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
</tr>
</tbody>
</table>

Source: SATISI Adapted by Blueprint (2004) [FRIDGE, 2005: 81]

More than 80% of tool rooms in South Africa have less than 20 employees and no tool rooms employ more than 200 people. All aspects in the South African economy that affects economic activities of SMMEs apply to the TDM industry, since most TDM manufacturers are small enterprises. These factors include compliance costs, skills shortage, safety and security. The following sections discuss four economic factors influencing the competitiveness of the South African TDM industry.
2.2.1 Compliance costs

The high compliance costs associated with starting businesses and hiring labour in South Africa constrain labour-intensive industries.

Since 1994, more than 1 000 items of new business legislation have been passed in South Africa, which were aimed primarily at regulating employment contracts and labour relations [Duncan, 2005:1]. The resulting compliance costs have been high. It is estimated that in 2004 South African enterprises incurred regulatory compliance costs of R79 billion, or around 6.5% of the GDP [Duncan, 2005:1]. For enterprises with annual sales of less than R1 million, compliance costs amount to 8.3% of turnover, while corporations with sales of R1 billion or more spend around 0.2% of their revenue [Duncan, 2005:1]. This depicts the heavy penalisation on SMMEs by labour regulations.

In a study to identify constraints to growth in South Africa, nearly 40% of respondents stated that the cumulative effect of business legislation reduces permanent employment [Chandra, Moorty, Nganou, Rajaratnam & Schaefer, 2001:32]. In particular, firms now hire fewer workers, substitute capital for labour during expansions, employ more temporary staff and sub-contract [Chandra et al., 2001:32].

In his State of the Nation address, President Mbeki [Mbeki, 2005] suggested that there might be relative deregulation of the SMME sector. It has been stated that 60% of total SMME applications for exemption from the Labour Relations Act has been granted in an April 2005 African National Congress (ANC) economic transformation committee workshop report [ANC, 2005].

2.2.2 Low investment levels

According to the Toolmakers Association of South Africa (TASA), TDM products have lower production runs in South Africa compared to their international counterparts. This results in a vicious cycle of producing lower quality products at lower prices in order to retrieve some profit from lower production runs. The current situation is that of the recovery of minimum profits with a lack of funds for investment in proper operational systems, equipment and training of personnel [FRIDGE, 2005:64].
The South African Centre for Scientific and Industrial Research (CSIR) indicates that South Africa’s production costs are significantly higher than its competitors. Low levels of investment over time in the necessary technology have apparently resulted in South Africans working with ageing technology/equipment and inefficient work methods as compared to competitor nations, even though competitive technology is available through linkages with technology institutions [FRIDGE, 2005:72].

2.2.3 Skills shortage

A severe skills shortage in South Africa constrains growth in the TDM industry. The current shortage in the supply of skilled personnel will result in an increase in labour cost in the near future. The rise in wage costs has already increased dramatically over the past five years. The following information shows this incline in personnel cost for the TDM industry:

*Table 2-2 Wage levels for skilled and semi-skilled employees*

<table>
<thead>
<tr>
<th>Skill level</th>
<th>2000</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-skilled wages</td>
<td>R9/h</td>
<td>R21/h</td>
<td>R25/h</td>
</tr>
<tr>
<td>Skilled artisan</td>
<td>R60/h</td>
<td>R100/h</td>
<td>R110/h</td>
</tr>
</tbody>
</table>

Source: FRIDGE, page 69

2.2.4 Capacity of tool rooms

Growth in domestic demand of TDM products increased with the expanding domestic economy, especially in demand for automotive tooling. Figure 2-1 on the following page shows the import trend of automotive tooling for the previous 5 years. Growth in the Automotive Industry will have as result a positive growth in the demand of tooling.
The tool-making industry is not taking advantage of the available opportunities in the domestic industry. There are various reasons for the lack of capacity with economies of scale being the central motive. South African tool rooms are generally small (refer to Figure 3-3 on page 27) with little capacity as compared to international counterparts.
TDM demand, especially in the automotive industry, needs the supply of a high variety of products. Most of the products are not within the manufacturing capacity of a single South African tool room. A study conducted by the centre of automotive research found that tooling supply from a small tool maker is not as competitive in selection of tools dies and related services as in a collaborative business model [Manufacturing Systems Group, 2002:25]. A tool room will not be commissioned by a large tooling procurement if the commission exceeds the capacity of the tool room (see Figure 2-2 above). The entire project could be lost to foreign imports. The result is a large amount of value-adding lost by the South African economy [Grech-Cumbo:2006]. Available capacity becomes underutilised when an order exceeds the capacity of a tool room. The commission will be lost in its entirety. Collaborative business models in the tooling industry have the potential of overcoming this capacity problem for smaller players in the industry.

A study conducted by the Manufacturing Systems Group for the Center for Automotive Research in the United States of America shows that the cost-saving benefits of a collaborative model can be significant. It is shown in this study that the immediate short-term savings on tools can approach 40% [Manufacturing Systems Group, 2002:34]. The bulleted extract shows that capacity improvement can be achieved through the following synergistic opportunities:

- Sales and marketing efforts.
- Development of standardised processes for bidding and resource deployment including functional build procedures and methods.
- Development of tooling standards.
- Standardised project management methods and software.
- Improved utilisation of coalition resources (e.g. engineering workstations and personnel, machining equipment, pattern shops, first-off tool tryout presses, etc.).
- Improved ability for small, niche shops to develop their expertise and still compete successfully on larger programs that would otherwise be beyond their ability.
- Financing resources and leverage for volume purchasing of standard components.

[Manufacturing Systems Group, 2002:35]
2.3 Success Factors for TDM Manufacturing

2.3.1 General Remarks

Success strategies cannot be determined through normal business administration techniques, since there are two well-known problems regarding these techniques. Firstly, assessment models that are only based on accounting statements of the previous financial year lack real time information. Secondly, a shortfall in grasping the origins of indicators in the value-added chain restraints the understanding of technological and human capital strength and human capabilities of the organisation [Bilsing & Klocke, 2004:323].

Eversheim and Deckert determined five success factors for tool, die and mould manufacturers [Eversheim & Deckert, 2001:179], namely:

- High motivation of personnel
- Focus on core competencies
- High effort in early phases
- Continuous investment in modern technologies
- Adequate NC programming strategy

The five success factors were identified through calculating a normalised indicator for the turnover profitability, return on investment, turnover development and capital turnover benchmarking indicators. Good performance in these indicators indicates profitable growth. A statistical study based on the 25% best performers and the 25% worst performers with profitable growth as performance measurement indicated five success patterns by comparing the averages of all other benchmarking indicators. The five success patterns are:

- **High Motivation of Personnel**
  High motivation is the basis of a successful company. Motivation is indicated through a low quota of absence and accidents in the workplace along with high commitment of workers. High motivation is crucial in achieving competitive results in the tool and die manufacturing environment.

- **Focus on Core Competencies**
  This success factor is the identification of and concentrating on core competencies to optimise the industrial value-added chain within a tool room. Any process, which can be
outsourced and where an organisation is not performing at a competitive level, should be outsourced. The manufacturer can then focus more resources and energy on processes in which he/she excels in order to deliver competitive value. Knowledge and experience in the production of products will increase when the number of different sectors in which clients are served, can be reduced. The effectiveness of a TDM manufacturer will improve through the above-mentioned core competencies. This effectiveness in turn is a prerequisite for efficient manufacturing.

3. **High Efforts in Planning Phase**
Allocation of production and process costs takes place during the planning phase. Effective planning and design have a significant reduction in production costs and lead times for the manufacturer. High effort in the planning phase of concept and process design and NC programming strategies will reap benefits later in terms of reduced engineering changes after the design has been released to manufacturing.

4. **Continuous Investment in Modern Technologies**
Continuous investments in modern technologies are necessary to keep up to date with developments regarding tool and die manufacturing. An adequate degree of automation offers opportunities for restructuring and streamlining. Technological advancement increases the competitiveness of an organisation. A lack in a good investment strategy will lower the competitiveness of a TDM manufacturer to unsustainable levels due to obsolete equipment and technologies.

5. **Adequate NC programming strategy**
An adequate NC programming strategy increases the throughput of the metal-cutting plant in a tool room. A high utilisation of machines will lead to a reduced hourly rate. An adequate NC programming strategy, with a focus on programming during machine running time instead of machine downtime will increase NC machine utilisation. This strategy will increase the total efficiency in the metal-cutting operations of the TDM manufacturer.

The above-mentioned success factors are not considering South African specific challenges, as indicated below. According to the FRIDGE study, “South Africa’s skills base is low by international standards and does not constitute a competitive advantage over its global counterparts. There exists a shortage of skilled workers at all levels of
TDM manufacturing and design. Even basic training and skills development infrastructure do not exist or are below standard" [FRIDGE, 2005:122].

The five success factors for tool, die and mould manufacturers [Eversheim and Deckert, 2001:179] were adapted to incorporate challenges unique to South Africa. The challenges in the South African industry are identified in chapter 4 and addressed in chapter 5. These challenges include:

1. **Shortage of skills and the lack of a skills development infrastructure**
   South Africa experiences a massive skills shortage in all spheres of manufacturing. As stated in the introduction and in the citation above, there is very little relevant training and development infrastructure available for the TDM industry in South Africa. The industry does not only require skilled employees, but experience as well (See paragraph 2.3.4).

2. **Attitude towards collaboration**
   During the apartheid regime, foreign sanctions forced the South African manufacturing industry to be introspective and self-sustaining. Domestic competition thrived under these circumstances. Today, nearly fifteen years after the demolishing of sanctions, the attitude of small business owners is still one of independent competition within the domestic industry, rather than collaboration to achieve global competitiveness.

3. **Attitude towards investment**
   The technologies employed by TDM manufacturers are mostly obsolete (See paragraph 2.3.3). Small business owners depreciate their equipment to receive maximum return on a low capital layout. Very little, if any, of the return becomes reinvested into modern technologies and processes on a consistent basis. The low level of investment across the South African TDM industry places a constraint on the global competitiveness of the industry.

The following adaptation of some of the success factors, as developed by the Laboratory for Machine Tools and Production Engineering (WZL) of the Aachen University of Technology in Germany, provides a framework from which the South African industry may be analysed and according to which future development solutions proposed.
2.3.2 Focus Ability - Concentrate on Core Competencies

The first identified success factor for a South African tool room is to concentrate on its core competencies. This success factor requires collaboration and shaping of tool room clusters in localised areas (See paragraph 5.1.2).

2.3.3 Technology Base - Investment in Modern Technologies

The second success factor is continuous and consistent investment in modern technologies. Technological advancement is a necessity to keep on par with the competitive advancement in the manufacturing sector of the world. Lack of a superior investment strategy will lower the competitiveness of a TDM to unsustainable levels due to obsolete equipment and technologies.

There are two reasons for the lack of investment infrastructure from financing institutions for TDMs in South Africa. Firstly, South African TDMs carry high levels of risk for commercial financing institutions since capital investment for TDM technologies comprises a very high percentage of the total capital layout for the manufacturer. Secondly, payment for work conducted can pose major cash flow shortages, which financing institutions are not willing to carry.

Successful investment models will require collaboration of tool rooms, after identification of core competencies. This can advance Government support for financing modern technologies to clusters of small tool rooms. Efficient utilisation of older technologies across the TDM industry is necessary in order to increase the competitiveness in production of work with lower technical requirements.

2.3.4 Skills Development

The die concept and design phases require highly skilled work, of which there is currently a major shortage in the domestic market [Venter, 2005:70]. Tool rooms need to establish training programmes for skilled design and programming engineers. This study found that only 5.2% of personnel in domestic tool rooms are academically qualified as compared to 7.3% in international tool rooms. 30.49% of personnel in South African tool rooms are unqualified while the corresponding indicator shows that a mere 7.2% of personnel in international organisations are unskilled.
Collaboration of tool rooms and the establishment of manufacturing clusters in smaller tool rooms will achieve the required work levels to justify the cost of training and utilising highly qualified design and programming engineers. Successfully deployed centres of excellence for tool making and manufacturing could give rise to more efficient training programmes. The cost of design technologies and Computer Aided Design (CAD) packages can be justified through collaborative ventures.

The estimated time to develop a skilled toolmaker is between seven and fifteen years according to research presented in an article in *Creamer Media’s Engineering News* [Venter, 2005:70]. Massive intervention is required by way of collaborative training programmes between tertiary education and training colleges and industry by creating centres of excellence to overcome the shortage of skilled toolmakers.

### 2.3.5 Efficient Manufacturing

Collaborative investment that identifies opportunities for efficient utilisation of technologies and resources within tool rooms through sharing resources can overcome the low level of modern technologies in South African TDMs. Adequate NC programming strategies, with a focus on programming during machine running time instead of machine downtime, across organisations can increase the efficiency of TDM manufacturing [Eversheim & Deckert, 2001:179]. High value-adding machining can only be achieved through efficient utilisation of the available NC machines in the entire domestic TDM industry. This comprises not only the time utilisation, but also the complexity of metal cutting on NC machines. Sharing of newer and older technologies can increase manufacturing efficiency. This strategy will increase the total efficiency in metal cutting operations for the TDM industry as a whole [Eversheim & Deckert, 2001:179]. Manufacturing resources can be utilised efficiently. An example is the waste generated through utilisation of NC machining for work that could be executed on a conventional machine. Collaboration can level effort amongst all available resources and reduce waste.

### 2.3.6 High Motivation of Personnel

The last success factor is high motivation and commitment of personnel in the organisation, which is crucial in achieving competitiveness of the TDM industry. The cost-saving measures in order to survive in the face of highly competitive imports resulted in neglect of in-house training, which fuelled the shortage of skilled personnel.
Tool rooms therefore need to concentrate on training and retention programmes. Specialised training programmes can be undertaken following tool room collaboration to share core competencies. Government support and marketing of the tooling industry are imperative in motivating new trainees and in increasing the skill levels of human capital in the tooling industry.

These success factors are not autonomous. Interdependence is crucial in analysing and understanding the performance of the South African TDM industry. The following diagram (Figure 2-2) depicts the five success factors and the related interaction.

*Figure 2-3* Success factors for the South African TDM industry

SOURCE: Adapted from Bilsing & Klocke, 2004:327.
The benchmarking model applied to conduct this study uses these success factors to determine the performance of a tool room or that of the industry under consideration.

The model was initially developed by WZL in Germany. Mr Hertzog reprogrammed the model in VBA for MS Excel and translated all the text to English. Some initial dry runs were done by Mr Hertzog to test the model against the German model [Hertzog]. It was found that, in live runs of the model, that some of the translation was ambiguous. Ambiguity was removed. The output was improved to cater for different subsets of data to be compared. The model was refined and the analysis procedure for benchmarking South African tool rooms is developed for the purpose of this study. The following chapter will elaborate on the benchmarking model.
3. BENCHMARKING METHODOLOGY

3.1 General

Benchmarking is a structured process to learn from practical experience through comparing a company’s capabilities directly to other competitors. The following citation describes four types of benchmarking:

“There are four types of benchmarking to be distinguished:

1. Internal benchmarking is being used to compare departments or sometimes locations of one company. This method can be realized relatively easily because it does not require an elaborate search for benchmarking partners. On the other hand new insights or strategies can be derived only to a very limited extent.

2. To get more substantial insights the comparison to outside companies is necessary. This is being done in a competitive benchmarking. Several partners from one sector get together to jointly analyse processes of interest. Due to the need for mutual trust it is usually difficult to find benchmarking partners from the same sector.

3. This obstacle can be avoided by comparing similar processes from different business areas in a functional benchmarking. This approach sometimes facilitates revolutionary solutions, but often those results cannot be transferred and applied to different sectors.

4. Generic benchmarking is taking one step further by comparing the same functions in companies from different sectors, which makes it possible to identify best solutions for general processes only.

For the analysis of several companies from the same sector (tool and die industry) a competitive benchmarking is most suited. It is enabling a continuous search for successful strategies and is a valuable tool for strategic orientation. The impartial evaluation of the own position using benchmarking data includes the identification of own strengths and weaknesses in relation to competitors. Aims for the benchmarking can be defined to be achieved in a given period of time considering own competencies and potentials and the ‘Best in Class’. A detailed analysis of benchmarking data can give hints on how to achieve the aims. In the long run, the success of implemented strategies can be verified by anew benchmarking tests (Eversheim) (Töpfer)” [Bilsing & Klocke, 2004:2-3].
3.2 Benchmarking Model

3.2.1 History of the Benchmarking Model

The Laboratory for Machine Tools and Production Engineering (WZL) of the Aachen University of Technology in Germany, developed a benchmarking model for tool rooms in the mid-1990s. In 2001, WZL granted a license agreement to the Global Competitiveness Centre in Engineering (GCC) at the Department of Industrial Engineering, University of Stellenbosch, to use and adapt the benchmarking model. This agreement is only valid for the purpose of non-commercial research. In 2003, the Department of Industrial Engineering at the University of Stellenbosch and WZL embarked upon an improvement project. The existing benchmarking model was adapted to address the specific problems faced by the South African tooling industry. The following improvements to the benchmarking model were suggested following the successful completion of a master’s degree in Engineering [Hertzog, 2004]:

- The user interface of the previous application was written for the German context and, as a result, the data-capturing questionnaire and user manual were in German. This significantly inhibited its application by South African users. The new application was translated into English and therefore more suited to the South African industry.

- Only relevant questions were included in the questionnaire while questions not relevant to the South African context were omitted.

- Some questions required data units with a yearly average over a three-year period. Some South African organisations might not have a three-year history, especially young companies. The new application allows the user to enter data based on any number of years. The time span for the information is known in the model as the time window. Data are compared through scaling by the time-window factor. This ensures that more companies, especially young companies with incomplete historical data, can be included in the benchmarking exercise.

- The graphical output of the initial model displayed output information for selected companies. No perspective with regard to the entire database could be shown. The new format of the output graphs includes the minimum, average, maximum and standard deviation of all entries in the database and not only the selected entries for specific comparisons. This ensures that a comparison is placed in context to the total database and furthermore ensures a more accurate interpretation of results.
Hertzog concluded his thesis by saying that the new programme will first have to be used for a real-life benchmark before the accuracy and efficiency of its output can be guaranteed. The above-mentioned changes to the benchmarking model improved its applicability to the South African industry, but a number of problems were still apparent when the benchmarking model was applied to three selected South African tool rooms in a pilot implementation.

3.2.2 Benchmarking Model Elements
This section provides a short description of the key elements in the benchmarking model. The elements are discussed in sequence of their use during the implementation of the benchmarking model in this study.

Data-capturing questionnaire
The data-capturing questionnaire (DCQ) was done as an MS Excel file containing questions to capture the required information for the calculation of performance indicators (PIs). The DCQ is shown in Appendix A of this report.

Input programme
The DCQ for each tool room is imported into an Excel database through a Visual Basic Applications (VBA) for Excel program. During the import process, the PIs are calculated from this information and this information is then stored in the database. The formulas used to calculate the PIs are listed in Appendix B of this report.

Database
The MS Excel database contains all the relevant information for each tool room. This is the captured data and the calculated PIs. Data includes the minimum, average and maximum values for all the indicators. Participating tool rooms in the benchmarking study are benchmarked against a database of 12 South African tool rooms (inclusive of the three selected tool rooms for the benchmarking implementation) and an international database consisting of approximately 50 tool rooms.

Output graphs
The VBA for Excel program produces output graphs for each performance indicator to perform the benchmarking analysis. Any number of tool rooms can be compared against each other and against the industry minimum, average and maximum values for each PI.
The minimum, average and maximum values for the PIs of the international database are separated from the same values for the domestic PIs. This allows for benchmarking analysis of the domestic industry against global competitors and an analysis of a single tool room’s performance against performance of the international and domestic industries. Figure 3-1 below is an example of an output graph for a PI.

![Performance indicator graph](image.png)

**Figure 3-1 Example of an output graph for a performance indicator**

Performance indicators
A total of 104 performance indicators are calculated for each tool room. Performance indicators pertain to:

- costs and cost distributions;
- technologies used in the tool room;
- skills levels of employees;
- order characteristics;
- characteristics for the supply of materials; and
- time allocation and resource utilisation.

The two performance indicators pertaining to productivity and turnover per employee are the **key performance indicators** with regard to the competitiveness of a tool room or a tooling industry.

Core statements
The indicators are grouped into 21 core statements. Each core statement carries relevant information concerning a certain aspect of the tool room. A short account of each core statement is provided in paragraph 3.3 of this report.
3.2.3 General Benchmarking Procedure

The general benchmarking procedure consists of four primary activities. Figure 3-2 shows the general benchmarking procedure in a breakdown of the sequential activities, the party responsible for each activity and the elements of the benchmarking model used in each activity.

![Figure 3-2 General benchmarking procedure](image)

A short description of each activity is given below.

Data capturing
The benchmarking model is introduced and presented to the participating tool room. The visit from the benchmarking analyst serves as an opportunity to explain the DCQ and the required information to be gathered by the tool room for a benchmarking analysis. The tool room (usually the owner or general manager) collects the required information and presents it to the benchmarking analyst. Appendix A presents a copy of the DCQ.
Observation and validation of the information
The plausibility check of the captured data is done by assessing the completeness of the DCQ. The tool room is notified of all missing data and the correct information is requested. The next step is to capture the data from the DCQ and to calculate the PIs through the input program (Appendix B presents the formulas for the calculation of the PIs). A preliminary benchmark is conducted (output graphs generated) to observe the plausibility of the PIs. Plausibility problems pertaining to data validity are documented and sent back to the tool room for correction. This process is iterative and continues until the data adheres to the plausibility checks. A list of plausibility checks are attached in Appendix C. The benchmarking analyst conducts this step in the benchmarking study.

Analysis and interpretation
Once it has been verified that the captured information is correct, the output graphs for a benchmarking study are produced. Tool rooms to be benchmarked against each other and against the industry are selected and the output graphs are generated. An analysis is conducted of the performance of a participating tool room against the identified success factors. “Best in class” performances are identified. The participating tool room is subsequently measured against the “best in class” performances. Areas of and possible reasons for poor performance are identified. Core statements depicting weak performance in the success factors are analysed and interpreted to identify competitive and uncompetitive business processes. These uncompetitive business processes within the tool room under consideration and for the total value chain of the industry, and the problems associated with these processes are identified and documented.

The benchmarking analyst and the tool room are involved in developing a comprehensive understanding of the tool room’s performance through a comparative study between the competitive and uncompetitive business activities within the tool room.

Recommendations
The final step is to develop recommendations for a tool room or for an industry as a whole. These recommendations can be very specific to a participating tool room or generic to the domestic industry. In the event of a tool room, the benchmarking analyst and the tool room will collaborate in the development of feasible recommendations. Recommendations are based on the analysis and interpretation of the PIs, core statements and performance in terms of the success factors.
This report interprets and analyses the South African TDM industry as a whole and provides recommendations to raise the global competitiveness of the industry. A case study of a specific benchmark for a selected tool room is attached to this document as Appendix D.

3.3 Benchmarking Database

The international database consists largely of German and other EU tool rooms with a small percentage of South American tool rooms. It is important to note that small companies with a relatively low number of employees do not form the majority of entries in the database (Figure 3-3). This allows small South African tool rooms to be benchmarked against world-class competitors. The advantage of larger organisations with a focus on supplying for specific industries can be observed and problems associated with small tool rooms in the global supply of TDM products can be identified through a benchmarking comparison against the world-class competitors.

The figure below depicts information pertaining to the location, product scope, and turnover and personnel structures of the international database.

![Figure 3-3 Representation of international database](image)

**SOURCE:** Laboratory for Machine Tools and Production Engineering (WZL) of the Aachen University of Technology
The 12 companies in the domestic database are not enough to perform conventional statistical analysis. Future benchmarks and participation of more tool rooms will expand the domestic database. A larger database will allow for better statistical validation and analysis and will also provide a more comprehensive understanding of the performance of the domestic industry.

### 3.4 Analysis Procedure

It is important to understand the capturing and representation of information in the benchmarking model. For further analysis of the information, clarification of two terminological usages is required. The first is the process chain, referring to the manufacturing of a tool, die or mould and the phases in this process. Capturing information relies on understanding of these phases as regards the activities within each phase, the resources consumed and the value created. The second concept is the representation of information through grouping performance indicators into core statements. Each core statement pertains to a delimited perspective of TDM activity. The next two paragraphs elaborate on the process chain and the core statements.

#### 3.4.1 Phases of the Process Chain

The benchmarking model recognises six phases in the process chain of TDM manufacturing. The diagram below shows the elements of the process chain for TDM production.

1. **Die concept and design**

   Every new tool, die or mould provides unique challenges since characteristics of components to be manufactured from tools, dies and moulds are becoming more demanding. Developing a concept and designing the tool requires skill and experience. Modern technologies in computer-aided design (CAD) significantly increase value added during the early phase of die concept and design.
2. Process Planning
Cost estimations and resource allocation throughout the tool-making process, as pertaining to the specific tool under consideration, are essential for effective manufacturing.

3. NC Programming
NC Programming is the task of generating NC cutter paths, cutting parameters, tool changes and any other required information for production on NC machines. New technologies in computer-aided manufacturing (CAM) allow for more efficient part programming and manufacturing.

4. Metal Cutting
Metal cutting is the process whereby metal removal is conducted to produce the required tool elements and special inserts. All the necessary components are prepared for assembly in this phase.

5. Finishing and Final Assembly
The final adjustments and fittings are done for components to be assembled. Necessary polishing to achieve the required finish is done as well.

6. First-off tool trail runs
Testing through trail runs and reworking to reduce any quality problems associated with the application of the tool (e.g. to identify and reduce flashing in plastic conversion).

The PIs in the benchmarking model relate to the phases of the process chain. Resource allocation, utilisation and cost distribution across the phases provide a clear understanding of effort spent in each phase of TDM manufacturing.

3.4.2 Core Statements
The performance indicators are grouped into 21 core statements. Each core statement carries relevant information for a certain aspect of the tool room. The following 21 descriptions offer a short account of the information depicted by each core statement and the possible deductions based on the information contained in each core statement.
CS1: Cost Distribution 1
Cost distribution 1 refers to the percentage internal costs associated with each phase in the process chain. Internal costs refer to the cost for each phase, where this cost is the total cost allocated to the phase, less any material cost incurred for the manufacturing phases.

The allocation of effort and the identification of core competencies to produce a tool are depicted by this core statement. Cost Distribution 1 shows whether resources are allocated efficiently in a tool room and the position of the tool room’s competencies. The percentage cost associated with the planning phases will be higher in more technologically advanced tool rooms.

CS2: Cost Distribution 2
Cost distribution 2 refers to the internal cost as a percentage of the total cost allocated to each of the following aspects within the tool room:
- personnel;
- depreciation;
- interest payable;
- external services;
- material; and
- overheads.

This statement provides information pertaining to the efficient utilisation of personnel and technology levels. Higher depreciation will show positive investment in modern technology, which will have a direct result to the percentage cost allocated to personnel. A judgment can be made on the skills levels, if the percentage cost allocated to these different aspects, especially personnel, is viewed in accordance with the technology levels and the number of productive employees in the tool room.

CS3: Cost Rates
This core statement refers to the ratio between the cost and the actual personnel hours utilised for each phase of the process chain. It comprises the operational cost per hour for each phase. An hourly rate for expenditure depicts the technology deployed within the tool room and the skills-levels of the personnel associated with each phase.
CS4: Time Utilisation

Time utilisation refers to the ratio between the allocated hours and the actual hours used for each phase in the process chain. Efficient planning of resources is depicted through this core statement. Poor performance in the Time Utilisation core statement is indicative of poor planning. Effective and correct planning is essential for cash flow in a tool room.

CS5: Core Competencies

This core statement refers to the percentage of work done in-house for each phase in the process chain, which translates to the manufacturing depth of each phase. The ability of a tool room to focus on its core competencies and the outsourcing of weaker performance areas can be observed through this core statement. A scenario of no clustering is prevalent if all tool rooms are trying to do everything in-house.

CS6: Personnel Distribution

Personnel distribution refers to the percentage personnel allocated to each phase in the process chain, measured by the number of employees in each phase concerning the total number of employees in the tool room. The skills levels and efficiency of personnel in the tool room can be deduced from this core statement. An above average percentage of personnel in certain phases of the process chain, as compared to the industry, depicts low efficiency of personnel and the possibility of under-skilled personnel.

CS7: Internal/External Cost Distribution

This is the estimated cost for each phase in the process chain concerning internal and external work done. The amount of work outsourced is incorporated into the cost by adding a cost component that is directly proportional to the actual cost allocated for work completed in the tool room. The ability of a tool room to focus on its core competencies in the manufacturing chain, and the costs allocated to outsourced processes to determine the competitiveness of suppliers are shown through the Internal/External Cost Distribution core statement.

CS8: Productivity

This core statement establishes an understanding of the tool room’s competitiveness and is a key performance indicator (KPI) in the analysis procedure of a tool room. The following four indicators depict the competitiveness:

- productivity measured in Euro per employee – a ratio between turnover less cost of materials and external services, and the number of employees in the tool room;
- the percentage of employees providing a directly productive contribution in all phases;
- the number of employees as a ratio of the number of managers/supervisors in non-manufacturing departments; and
- the number of employees as a ratio of the number of managers/supervisors in manufacturing departments.

A hypothesis for the competitiveness of a tool room is based on its productivity. The KPIs in this core statement depict the productivity of employees, which shows universal performance of the tool room through all phases in the process chain. Poor performance in productivity may be ascribed to uncompetitive performance in any combination of success factors. Uncompetitive performance areas are identified through an analysis of the success factors.

**CS9: Skills levels**

This has to do with the percentage of employees in all phases with a qualification of the following types:
- academic qualification;
- technical qualification/toolmakers;
- supervisory position;
- unskilled; and
- apprentice.

The skills levels of employees are determined by this core statement.

**CS10: Motivation of Employees**

This statement indicates the illness figure of wage earners, accident frequency and downtime due to accidents. Employees with low morale and lack of motivation tend to have higher illness figures and such employees are more prone to accidents in the workplace than motivated employees with high morale. A good, clean working environment reduces accidents and increases employee motivation.

**CS11: Technical Level**

The technical level depicts the number of the following types of metal cutting machines in a tool room:
- 3-axis milling machines;
- 5-axis milling machines;
- high speed cutting (HSC) milling;
- grinding;
- electronic discharge machining (EDM);
- presses; and
- measuring.

The *technical level* depicts the capabilities and technical advancement of a tool room. The core competencies in the execution phases of the process chain can be deduced from the technical capabilities.

**CS12: Automation 1 – Equipment Capabilities**

This core statement refers to the operating time without a machine operator as a percentage of the total operating time for milling, grinding and EDM operations.

*Automation 1* further depicts how well operational time of equipment is utilised by operators and the capabilities of the equipment. If the equipment and personnel in the tool room are operating below capacity, the information portrayed by this core statement can be misinterpreted, since the demand on the tool room is not high enough to justify automated manufacturing. The tool room is overcapitalised if time utilisation (Core Statement 4) is competitive, but Automation 1 is not. If time utilisation and automation are not competitive the skills and experience of machine operators are poor or the technologies are obsolete.

**CS13: Automation 2 – Organisational Capabilities**

Automation 2 refers to the multi-machine handling per employee for milling, grinding and EDM operations. The values in this core statement refer to the average number of machines that can be operated simultaneously per employee for milling, grinding and EDM operations. The same conclusion can be drawn for this core statement as for the previous automation core statement.

**CS14: Client and Supplier Base**

This core statement refers to the number of:
- industries (branches) to which a tool room supplies;
- different countries being supplied;
- clients being supplied; and
- clients purchasing more than 10% of the total sales from the tool room.

The ability of a tool room to focus on a specific industry, with similar products and production methods, is depicted through the client and supplier base. It is beneficial for a
tool room to service a low number of industries. Knowledge and experience can be
developed and maintained for specific industries, where the tool room can develop a
niche. A high number of suppliers will show bargaining power in acquisition of material
and equipment.

**CS15: NC Technical Level**

This core statement refers to the NC utilisation in a tool room, in terms of the NC
technology base and the efficient use of NC technology concerning:
- the percentage actual time NC machines are used compared to the total machine
  usage;
- the percentage NC machines in terms of all machines in the tool room;
- the NC programming time in terms of:
  - central processing time;
  - machine downtime; and
  - machine usage; and
- the actual time NC machines are used compared to the total NC programming time.

This core statement shows the efficient utilisation of NC capabilities in the tool room. NC
machines require high capital layout, and should be optimally deployed for metal cutting.
Uncompetitive utilisation of NC capabilities shows potential for collaboration with other
tool rooms, to increase utilisation of such tool rooms.

**CS16: Quotation Characteristics**

The quotation characteristics core statement depicts the following information regarding
orders:
- the number of quotes to be converted into orders;
- the number of alteration orders compared to new orders; and
- the percentage of orders completed in time as stipulated in the quote.

This core statement shows the ability of a tool room to do planning and cost estimation
correctly. Cost estimation and project planning are essential skills in tool rooms,
especially with competitive tendering being a key factor in receiving orders from quotes.

**CS17: Order Characteristics**

The order characteristics core statement depicts the following average values
- of all new orders;
of products completed in the tool room per day (the daily order value created); and
for the amount of productive hours spent on an order per day.

The manufacturing capacity of a tool room can be determined through the order characteristics. Efficiency throughout the process chain is shown by the amount of productive hours spent per order per day. Correct planning and allocation of available resources in the tool room will have competitive order characteristics as a result.

**CS18: Types of Orders**
This refers to the percentage of cost spent on the following types of orders:
- new orders;
- alteration orders;
- maintenance orders; and
- repair orders.

Types of orders is related to the quality of work conducted, since alteration, maintenance and repair orders will predominantly be for previously new orders from the same tool room.

**CS19: Cost and Productivity**
This core statement establishes an understanding of a tool room’s competitiveness and is a key performance indicator in the analysis procedure. The following six indicators depict competitiveness:
- annual turnover generated per employee;
- turnover profitability, i.e. operating profit as a percentage of turnover;
- return on capital employed, i.e. operating profit as a percentage of all assets;
- capital turnover, i.e. turnover as a percentage of capital assets;
- investment expenditures as a percentage of costs; and
- all costs for the production phases expressed as a value per employee.

A hypothesis for the competitiveness of a tool room is based on the productivity. The KPIs in this core statement provide information on the productive and competitive utilisation of the capital layout in tool rooms. Low levels of investment and poor utilisation of the available capital layout are uncompetitive. The performance of the success factors will show specific areas for improvement in the cost and productivity core statement.
CS20: Wages
Costs as regards wage earners and the efficiency of personnel are shown through the following indicators:

- average hourly wage for wage earners;
- all additional labour costs (anything above normal wages) calculated as an hourly cost;
- the allocated personnel hours as an percentage of the actual personnel hours;
- the amount of machine hours for every hour of metal cutting;
- utilisation of machine capacity; and
- the percentage of employees earning incentive wages.

This core statement shows the utilisation cost of personnel and the utilisation of personnel resources. The most competitive scenario is low personnel costs and efficient utilisation of personnel hours.

CS21: CAD Technical Level
This core statement shows the computer-aided design technical level through the following PIs:

- amount of CAD employees as a ratio of the amount of directly productive employees;
- the initial design and manufacturing time compared to testing and reworking of a finished product before commissioning.

This concludes the clarification of the 21 core statements in the benchmarking model.

3.4.3 Relevance of the Core Statements to the Success Factors
The 21 core statements provide information about the five success factors of TDM manufacturing. Table 3-1 below shows performance in the success factors through the relevance of each core statement by intuitive inference. A core statement can have no relevance, or it may have a slight, moderate or strong relevance to any one of the success factors.

CS8: Productivity and CS19: Cost and productivity have strong relevance to all five success factors. Based on this characteristic, the performance indicators in these two
core statements are regarded as the key performance indicators for stating the hypothesis and for further analysis of a tool room’s performance.

More information as regards the relevance of core statements to success factors may become apparent as the database expands with future benchmarks. Table 3-1 below is dynamic and subject to future change.

*Table 3-1 Relevance of core statements to success factors*

<table>
<thead>
<tr>
<th>Core Statements</th>
<th>Focus Ability</th>
<th>Technology Base</th>
<th>Skills Development</th>
<th>Efficiency</th>
<th>Motivation</th>
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</thead>
<tbody>
<tr>
<td>CS1: Cost Distribution 1</td>
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<td>CS2: Cost Distribution 2</td>
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<td>CS3: Cost Rates</td>
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<td>CS4: Time Utilisation</td>
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<td>CS5: Core Competencies</td>
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<td>CS6: Personnel Distribution</td>
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<td>CS7: Internal/External Cost Distribution</td>
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<td>CS8: Productivity</td>
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<td>CS10: Motivation of Employees</td>
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<td>CS13: Automation 2</td>
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<td>CS14: Client and Supplier Base</td>
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**Relationship Influence**

- ○ Slight
- ○○ Moderate
- ○○○ Strong
3.4.4 Hypothesis Statement

The initiation for analysis of an industry or individual TDM manufacturer’s performance in comparison to global performance is to hypothesise the performance. CS8 (Productivity) and CS19 (Cost and productivity) serve as the basis for the postulation of performance in the five success factors, since these two core statements depict performance in all five success factors.

The following indicators in the productivity core statement are used as basis for the hypothesis:

1. Productivity, i.e. the ratio between turnover of the tool room less cost of materials and external services, and the number of employees in the tool room; and
2. Percentage of directly productive employees, i.e. the percentage directly productive employees compared to the total number of employees.

Total tool room performance can be postulated in the following ways based on the information portrayed by the KPIs:

**Productivity**

The performance of a tool room can be postulated with respect to the following deductions, based on the productivity KPI:

1. Value created per employee will be higher if the tool room focuses on industry-specific products. This focus will increase knowledge of the required products, skill in manufacturing the products and the advantage of creating a niche in a specific industry. A strong focus on core competencies in the process chain, to suit the product range of the tool room, will reduce overcapitalisation in non-core competencies and will allow for skills development in the core competencies. The result will be higher productive output per employee in the tool room.
2. Utilisation of modern technologies, which is in line with the industries being supplied, will result in higher productive output per employee.
3. Suitably skilled employees will create higher value.
4. Efficient allocation of resources and technologies throughout the process chain (with outsourcing of inefficient processes) will result in higher productivity.
5. Productive output reduces significantly with unmotivated personnel.
Percentage of directly productive employees
Allocation of personnel, the highest cost contributor in TDM manufacturing, should be done in such a way as to increase productive output and to achieve optimal performance in the five success factors. The performance of a tool room can be postulated with respect to the following deductions based on the percentage of directly productive employees KPI:

1. Costs are absorbed through non-productive employees, which results in poor competitive performance.
2. A high level of skills in administrative and non-productive tasks should reduce personnel in this aspect of tool making. Skills in die concept and design and NC programming should be in line with the technologies and capabilities of the tool room.
3. Project-management and cost-estimation skills reduce the need for unproductive personnel and cost allocation.

The following KPIs in the cost and productivity core statement are used as a basis for the hypothesis:

1. Turnover, i.e. turnover of the tool room divided by the total number of employees expressed as €000 per employee (all monitory values in the benchmarking model are converted to Euro. This allows for benchmarks of TDMs in regions with different monitory units.)
2. Turnover profitability, i.e. profit (turnover less all costs) divided by turnover.

The hypothesis for tool room performance is based on the following association between the turnover and turnover profitability core statements (Figure 3-5).
Scenario 1:
In the Scenario 1 quadrant, the tool room, as benchmarked against competitors, is not competitive at all. An analysis of performance in the five success factors will clarify all possible problem areas from which improvement strategies can be developed.

Scenario 2:
A high turnover but low profitability depicts a second scenario where unproductive activities are absorbing profits of the organisation. There can be two reasons for absorbing profits. Firstly, investment in skills development, or costs associated with investment and expansion of the technology base absorbs profits, but with an indirect positive result through an increase in competitiveness. The second reason is unproductive activities with no direct or indirect benefit to the tool room. Restructuring of the tool room’s business processes will be required if unproductive activities are absorbing profits. In this scenario, an SMME needs to achieve growth and development through reinvestment of profitable returns.

Scenario 3:
Sole-owned tool rooms usually find themselves in this scenario. Profitability is maximised, usually at the expense of continuous improvement. This allows the owner to maximise his/her return on investment. This scenario will eventually lower the
comparative competitiveness of a tool room and can be detrimental to the sustainability of such an enterprise.

**Scenario 4:**
Scenario 4 comprises a situation in which the TDM manufacturer is in an established market. Technologies are readily available and margins for standard products are too competitive to allow a tool room the sustainability of high turnover from which high profits can be received. A tool room should invest in high added-value tools and should reinvest returns to maintain competitiveness.

This concludes the explanation of relevant information that serves as basis for a hypothesis statement concerning the competitiveness of a tool room or a tooling sector. The next step is to determine the performance in each success factor. Not enough evidence to reject the hypothesis or enough evidence to reject the hypothesis is obtained through systematic analysis of the tool room performance in the success factors. Performance in a success factor is measured by determining the desired competitive capabilities of the tool room as a result of comparison with the best “in class” performers in the benchmarking study.

3.4.5 Analysis Procedure
An independent analysis is conducted for each success factor, by systematically observing and interpreting the performance in the core statements relative to the success factor. The five procedures for analysis of performance in the success factors are referred to as the analysis procedures (AP). The diagram on the following page (Figure 3-6) depicts the logical process for analysing a tool room’s performance.

Analysis relies on inspection of core statements relevant to the success factor under consideration in a sequential manner. This inspection allows interpretation of a tool room’s performance, as compared to performance in the industry. Recommendations can be developed from this interpretation. The core statements relevant to a success factor are used to analyse the performance of a tool room in the success factor. The core statements support the hypothesis statement.
The next five paragraphs will describe the analysis procedure for each success factor.

**Analysis procedure for focus ability**

A study of the following core statements, as portrayed by the flow chart for the focus ability analysis procedure (Figure 3-7), offers support for the hypothesis statement in the form of how well a tool room is focusing its knowledge, technologies and resources to achieve competitiveness.
CS1 allows the analyst to identify the resource allocation to phases in the process chain. The analyst may deduct two possible insights from studying CS1.

Table 3-2 Possible consequences of cost distribution on focus ability

<table>
<thead>
<tr>
<th>% OF COST ALLOCATION TO A PHASE</th>
<th>ADVANTAGEOUS CONSEQUENCE</th>
<th>NEGATIVE CONSEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABOVE AVERAGE</td>
<td>1a</td>
<td>1b</td>
</tr>
<tr>
<td></td>
<td>Core competency in which the organisation excels and specialises.</td>
<td>Inefficient utilisation of resources. Not a core competency. Outsourcing is an option.</td>
</tr>
<tr>
<td>BELOW AVERAGE</td>
<td>2a</td>
<td>2b</td>
</tr>
<tr>
<td></td>
<td>Efficient utilisation of resources and/or successful outsourcing of non-core competencies.</td>
<td>Squeezing profitability from a process that is in line with the core competencies of the tool room.</td>
</tr>
</tbody>
</table>
Observation of CS7 allows for the identification of internal as well as outsourced effort allocated to the phases of the process chain. The value of outsourcing can be determined for a tool room, and for the effort allocated to all the phases in the process chain. If an above average percentage cost is allocated to a phase, it can be assumed that the tool room serves a niche market requiring higher effort of the phase under consideration. If this is not the case, it is evident that the specific phase is absorbing unnecessary costs.

CS5 offers a clear view of what percentage of work in each phase is outsourced. Provision of products to a niche market and the available technologies and skills in the tool room play a significant role in processes that should be outsourced and those that should not. This can be determined by observing CS11 and CS21.

The final interpretation in the focus ability of a tool room is to study CS14. The number of industries supplied compared to the number of clients gives a clear indication of how well the tool room is focusing its knowledge in producing for niche markets.

**Analysis procedure for technology base**

A study of the following core statements, as portrayed by the flow chart for the technology base analysis procedure (Figure 3-8), gives support for the hypothesis in the form of how advanced a tool room’s technology base is and how aligned it is with its business activities.
CS1 indicates a strong or weak technology base according to the scenarios as set out in the Table 3-3 on the following page.

The percentage cost allocated to interest and to depreciation, as part of CS2, offers insight into the investment strategy of the tool room. A strong and consistent investment strategy in modern technologies is necessary for achievement of global competitiveness.

Cost rates in CS3 will be higher for tool rooms with an advanced technology base. More costs will be allocated to production activities, which will result in higher productivity. The actual hours allocated to each activity will remain constant or might even reduce with automation brought on by modern technologies.

CS11, CS12 and CS13 describe technologies in a tool room quantitatively and indicate how these technologies measure up to the industry and the global standard. The automation core statements provide insights into how well the technologies are used and how multi-skilled employees increase technology utilisation.
Table 3-3 Consequences of cost allocation to phases of the process chain

<table>
<thead>
<tr>
<th>PHASES</th>
<th>PERCENTAGE COST ALLOCATION</th>
<th>CONSEQUENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning phases</td>
<td>Above average</td>
<td>Indicative of a strong technology base.</td>
</tr>
<tr>
<td>Manufacturing phases</td>
<td>Below average</td>
<td>Advanced techniques for design and NC programming.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expensive techniques that reduce manufacturing time and cost significantly.</td>
</tr>
<tr>
<td>Planning phases</td>
<td>Below average</td>
<td>Indicative of a weak technology base.</td>
</tr>
<tr>
<td>Manufacturing phases</td>
<td>Above average</td>
<td>Labour-intensive manufacturing techniques on obsolete technologies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very little application of modern technologies in concept design and programming.</td>
</tr>
</tbody>
</table>

CS15 and CS21 provide insight into the available NC technologies in a tool room. NC machining increases productivity significantly, especially when NC technologies are applied to appropriate machining and when this machining is utilised at its full potential.

The final interpretation in the technology base is CS17. This core statement offers information on the costs of orders, the order value created measured per day and the productivity of orders. A good technology base with low values for the mentioned KPIs is indicative of poor application of the available technologies. Good performance in these KPIs is essential in achieving global competitiveness.

**Analysis procedure for skills**

A study of the core statements, as portrayed by the flow chart for the skills analysis procedure (Figure 3-9), offers support for the hypothesis in the form of how good a tool room’s skills and skills development strategies are in order to achieve competitiveness in all business activities.
CS2 depicts the percentage of cost allocated to personnel in a tool room. This information in itself does not provide insight into the skills levels within a tool room. Information about the skills success factor can be inferred from CS2 by means of comparing a tool room with counterparts in the same economic environment. High-skilled labour is more expensive per employee, but production costs regarding other aspects of tool making increase with high-skilled labour. Skills required for advanced tool making will increase as automation increases as a result of utilisation of modern technologies. This will have fewer employees as a result. Higher percentage employees will be required in the early phases and less in the manufacturing phases as automation increase with modern technology (CS6). The required skills within a tool room needs to adapt with investment modern technologies. These reasons as mentioned diffuse the possibility of using this core statement as a stand-alone source of information.

Personnel distribution provides information about the allocation of personnel in the phases of the process chain (CS6). These allocations should preferably be in line with the focus of the tool room, as discussed under the focus ability. If not, the skills allocation in the tool room is not competitive.
CS3 provides insight into how well employees are utilising the available time to expend resources in the production of tools and dies. A higher cost rate generally signifies higher skills levels. It is essential to have adequate skills in the processes in which the tool room is establishing a niche.

The above information is consolidated by studying CS9, the skills levels in the tool room. Employee skills are essential in competitiveness. Experienced cost estimators and project managers with a tertiary education are a competitive advantage. Planning and resource allocation can significantly increase competitiveness and can assist with accurate quotations to clients. Personnel should be skilled at operating technologies at the most efficient levels.

CS12 and CS13 provide insight into the skills and experience levels of toolmakers in the workshop of a tool room. A low capability regarding multi-machine handling is not competitive. In the event of low automation, skills development and training are essential to achieve competitiveness. Multi-skilled employees reduce the risk of manufacturing downtime in the event of absenteeism.

**Analysis procedure for efficiency**

A study of the following core statements, as portrayed by the flow chart for the efficiency analysis procedure (Figure 3-10), offers support for the hypothesis in the form of how efficient a tool room is in utilising available resources, including personnel, costs, material and time.

Personnel distribution (CS6) and cost rates (CS3) provide insight into the distribution and allocation of resources in a tool room. It is essential to understand resource allocation when efficiency of utilisation is determined. The table below depicts the possible scenarios for each phase in the process chain through inspection of CS6 and CS3.
Below average values for time utilisation (CS4) in any phase of the process chain depicts inefficient business activities in a particular phase. Above average time utilisation depicts competitive utilisation of available resources in a particular phase.

Cost of NC technologies is high with a large capital layout as a result. Below average utilisation of NC technologies (CS15, NC technical level) is not competitive. The NC rate for metal cutting PI should correlate to the percentage of NC machines in a tool room. A high value for the NC rate of metal cutting, when compared to the percentage NC machines, will depict efficient utilisation of the capital deployed on NC technologies.

The quotation characteristics core statement (CS 16) allows the following interpretations. A high number of offering conversions and a high percentage in-due-time orders depict efficient cost estimation and process planning in the tool room. A low percentage of tertiary educated employees in the tool room in conjunction with values below the industry standard for the above indicators indicate a shortage of skills for efficient cost estimation and process planning.
Table 3-4 Resource allocation in a tool room

<table>
<thead>
<tr>
<th>PERCENTAGE PERSONNEL</th>
<th>COST RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELOW AVERAGE</td>
<td>ABOVE AVERAGE</td>
</tr>
<tr>
<td>X</td>
<td>x</td>
</tr>
</tbody>
</table>

i) Resource allocation is not in line with business activities if Focus Ability depicts a strong focus in this manufacturing phase.

ii) Resource allocation is in line with business activities if Focus Ability depicts a low focus in this manufacturing phase.

This is an unlikely scenario, since personnel cost is the greatest cost driver and will therefore influence cost rates positively. Costs allocated to personnel in this scenario are not in line with market trends.

i) Resource allocation is in line with business activities if the Technology Base depicts older technologies with low levels of automation.

ii) Resource allocation is not in line with business activities if the Technology Base depicts modern technologies with high levels of automation.

i) Resource allocation is in line with business activities if Focus Ability depicts a strong focus in this manufacturing phase.

ii) Resource allocation is not in line with business activities if Focus Ability depicts a low focus in this manufacturing phase.
Order characteristics, core statement 17, offers valuable insight into efficiency when viewed in conjunction with the focus ability, technology base and skills levels of a tool room or industry.

Table 3-5 Interpretation matrix of order characteristics

<table>
<thead>
<tr>
<th>CS</th>
<th>INFLUENCE</th>
<th>COST PER ORDER</th>
<th>DAILY ORDER VALUE CREATED</th>
<th>PRODUCTIVITY OF ORDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Ability</td>
<td>Good</td>
<td>Low 1 High 2</td>
<td>Low 1 High 2</td>
<td>1 2</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td></td>
<td>Low 3 High 3</td>
<td>3 3</td>
</tr>
<tr>
<td>Technical Base</td>
<td>Good</td>
<td>1 2</td>
<td>1 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>3 3</td>
<td>3 3</td>
<td></td>
</tr>
<tr>
<td>Skills Levels</td>
<td>Good</td>
<td></td>
<td>4 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td></td>
<td>6 6</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation of the different scenarios for the performance indicator influence on the core statements as numbered in Table 3-5 above follows.

Cost per order PI:
1. Under-utilisation of capital layout of a good technology base by producing low-value simple products is not efficient.
2. A tool room uses technologies efficiently when a good technology base produces high-value and complex products.
3. It is not viable for a tool room with a low technology base to produce high-value complex tools.

Daily order value created PI:
1. Creating a low daily order value with a good technology base is not efficient.
2. Creating a high daily order value with a good technology base is efficient.
3. It is not viable for a tool room with a poor technology base to create a high daily order value.

4. A tool room does not put good skills levels to efficient use in the event of a low daily order value created.

5. A tool room puts good skills levels to efficient use in the event of a high daily order value created.

6. Poor skills levels will not create a high daily order value.

Productivity of orders PI:

1. Inefficiencies are apparent when a tool room has good focus ability, but where the productivity of orders is low.

2. A tool room is efficient when good focus ability with a high productivity of orders is evident.

3. Poor focus ability will not result in good productivity of orders.

Core Statement 20, Wages, provides information on how efficiently personnel are utilising equipment. Weak performance at the time of actual metal cutting as a percentage of the total time for machine usage depicts inefficient utilisation of machine capacity by employees while operating machines. Capacity of production equipment depicts the time utilisation of machines. Tool rooms can increase efficiency by increasing the actual time of machine usage through the addition of extra work hours.

**Analysis procedure for motivation**

A study of the core statements, as portrayed by the flow chart for the motivation analysis procedure (Figure 3-11), offers support for the hypothesis in the form of how motivated employees are in a tool room.
Motivation of employees, CS10, depicts the illness figures of wage earners. Above average illness figures are indicative of poor motivation in the tool room. High illness figures in conjunction with poor employee productivity, as shown by the Wages core statement, CS20, are a sign of low employee morale. Poor wages and low empowerment incentives diminish employee motivation with resulting poor efficiency and execution of tasks. The consequence will be weak competitiveness of tool manufacturing.

3.4.6 Development of Recommendations
Performance analysis in the five success factors, as explained in the previous section of this chapter, provides support for the hypothesis statement. Underperformance in any number of success factors forms the basis for the development of recommendations to improve competitiveness.

Benchmarking the performance of a tool room against industry leaders allows the organisation to identify competencies that need development. The analysis of performance allows for the systematic identification of areas that experience underperformance, while at the same time, the observation of leading performances depicts the conditions to which a tool room should aspire.

Analysing industry performance allows a tool room to identify the production requirements to achieve competitiveness. The analysis procedure for the five success factors establishes the current capabilities and performance of a tool room. Identifying the performance shortfalls in the success factors offers assistance in the development of
strategies to close the gap between the required production capabilities and the current performance. The strategy to close the gap should incorporate the focus of the tool room in production technologies and niche markets. The investment and skills development strategies should be in line with the environment of the tool room. It is extremely beneficial to benchmark organisations against all possible counterparts in the dataset as well as all counterparts experiencing the same economic environment as the tool room under consideration. This allows for identification of best practices and for the identification of available opportunities in the immediate economic environment.

The following six-step strategy is a systematic approach to development recommendations:

1. **Conduct a benchmarking study**
   Conduct a benchmarking study as set out in paragraph 3.2.3 of this report. Annual repetition of benchmarking will produce the most possible benefit through comparison between counterparts and previous performance.

2. **Hypothesis statement and analysis of performance in the five success factors**
   Determine the current performance and capabilities through the analysis procedures as set out in paragraph 3.4.4 of this report.

3. **Identify required performance**
   Identify the required performance and capabilities through the analysis procedures as set out in paragraph 3.4.5 of this report.

4. **Identify the gap between current performance and required performance**
   Identify and document the variance between leading competitive performance and the current capabilities.

5. **Development of strategies to close the gap**
   Strategies should be line with the success factors and the immediate economic environment. Specify the implementation of the strategies. Identify test and evaluation procedures for the implementation of the developed strategies.

6. **Implement the strategies**
   Implement the strategies. Evaluate the success of the strategies through following up benchmarks.
4. BENCHMARKING SOUTH AFRICAN TDM MANUFACTURERS

4.1 Benchmarking Exercise

This section presents the results obtained through a pilot implementation of the benchmarking model. Three selected South African tool rooms were benchmarked against their local and global counterparts and each other, as set out in paragraph 3.3. A report as presented to a tool room serves as a case study and is provided as Appendix D to this report. The purpose of this chapter is to give a benchmarking analysis of the South African TDM industry as a whole against its global counterparts, and not to give a tool room-specific benchmark. The general performance of 12 South African tool rooms is compared with the international TDM industry.

4.2 South African TDM Industry Performance

This section presents the performance, conclusions and recommendations for the South African TDM industry, as based on the analysis procedure developed in Paragraph 3.4.

4.2.1 Hypothesis Statement

![Figure 4-1 CS8 KPI: Productivity](image)

The South African industry is performing at nearly half its productive output, when compared to their international counterparts.
The following hypotheses are postulated from the Productivity KPI:

1. a poor focus by South African TDMs on specific markets and products diminishes knowledge and experience in the productive manufacturing of products;
2. South African TDMs are not investing and utilising modern technologies efficiently;
3. employees are not suitably skilled;
4. allocation and utilisation of resources are not efficient; and
5. personnel in tool rooms are not motivated.

![Figure 4-2 CS8 KPI: Percentage directly productive employees](image)

TDMs in South Africa have a slightly below average percentage of productive employees compared to their international counterparts.

The following hypotheses are postulated from the percentage directly productive employees KPI:

1. costs are absorbed through non-productive employees, which results in poor competitive performance;
2. there is a below average level of skills in administrative and non-productive tasks. Unproductive cost and personnel allocation is uncompetitive; and
3. project-management and cost-estimation skills reduce the need for unproductive personnel and cost allocation;
4.2.2 Analysis of South African TDMs

Analysis of the five success factors will support the hypothesis as set out above. Identification of specific problem areas and the development of a desired position will follow from the analysis. The analysis concerns itself only with significant information. This implies that redundant analysis steps, as set out in chapter three, will be ignored. It can be assumed that information relevant to the success factor under consideration had
Focus Ability
The benchmarking study depicts the following cost distributions for the domestic TDM and international TDM industries:

![Image of bar chart showing percentage cost (internal) for die concept and design]

**Figure 4-5 CS1 PI: Percentage cost (internal) for die concept and design**

The domestic TDM industry allocates a lower percentage cost to die concept and design above (Figure 4-5), while percentage cost allocated to NC programming is high as shown below (Figure 4-6).

![Image of bar chart showing percentage cost (internal) for NC programming]

**Figure 4-6 CS1 PI: Percentage cost (internal) for NC programming**

The low effort allocated to die concept and design in the domestic industry is not competitive, since the opportunity to influence the required effort downstream is at an optimum during the early phases. The percentage cost allocated to NC programming is
indicative of low investment in required skills and modern software applications. The high cost allocated to NC programming can be reduced through investment in the required skills and in modern technologies. This will reduce the effort during the manufacturing phases.

Metal cutting consumes a large percentage of costs in the domestic industry as shown below (Figure 4-7).

First-off tool trial runs consume an exorbitant percentage of the cost, as compared to the international average (Figure 4-8).

It is apparent from analysing the cost distribution that domestic TDMs are not focusing enough effort in the planning phases of tool making. The result is above average cost allocation to NC programming and metal cutting with an extremely high cost allocation to product rework. The opportunity to influence the required effort in the manufacturing
phases with the lowest possible outlay lies in the ability to focus effort in the early phases.

CS5, Core Competencies allows for the following observations based on the information as portrayed in Table 4-1:

*Table 4-1 Percentage of effort per phase of the process chain incurred in-house*

<table>
<thead>
<tr>
<th>CS5: CORE COMPETENCIES</th>
<th>DOMESTIC</th>
<th>INTERNATIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>Percentage of die concept and design incurred in-house</td>
<td>10.00</td>
<td>78.70</td>
</tr>
<tr>
<td>Percentage of process-planning incurred in-house</td>
<td>97.00</td>
<td>99.91</td>
</tr>
<tr>
<td>Percentage of NC-programming incurred in-house</td>
<td>60.00</td>
<td>95.61</td>
</tr>
<tr>
<td>Percentage of metal-cutting incurred in-house</td>
<td>50.00</td>
<td>82.53</td>
</tr>
<tr>
<td>Percentage of finishing/final assembly incurred in-house</td>
<td>66.00</td>
<td>97.08</td>
</tr>
</tbody>
</table>

The above information shows that domestic TDMs and international TDMs tend to do a high percentage of work in-house. This was found to be a poor strategy. The domestic TDM industry should aim to increase collaboration with regard to niche activities in the process. This will provide the domestic industry with a competitive advantage through the opportunity to focus and build experience in specific activities.

There is not a strong focus on NC machining in the domestic industry as shown in Figure 4-9 below. The number of CAD employees as a percentage of the directly productive employees for the domestic industry is far below average (Figure 4-10). Modern technologies allow a tool room to increase value through focusing on the planning phases of tool making. The lack of focus on NC technologies and planning increases costs in the realisation phases and lowers competitiveness significantly.
The average number of industries supplied e.g. electronic, plumbing or automotive (Figure 4-11), in conjunction with the total number of clients (Figure 4-12) offers a good understanding of how well a tool room is focusing its knowledge and experience on niche markets.
The following ratio as used to determine the focus on specific industries:

\[ r = \frac{\text{Clients}}{\text{Industries}} \]

Table 4-2 Number of clients serviced per industry

<table>
<thead>
<tr>
<th>PERFORMANCE INDICATOR</th>
<th>DOMESTIC AVERAGE</th>
<th>INTERNATIONAL AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of clients</td>
<td>39.17</td>
<td>37.04</td>
</tr>
<tr>
<td>Number of industries</td>
<td>7.08</td>
<td>3.06</td>
</tr>
<tr>
<td>Ratio: Number of clients / Number of industries</td>
<td>5.53</td>
<td>12.10</td>
</tr>
</tbody>
</table>

Table 4-2 above shows that the domestic TDM industry does not focus its knowledge and experience on specific industries to gain competitive advantage. To focus tooling supply on niche markets, a tool room will be able to benefit from developing a knowledge base with regards to the industry demands and a strong client supplier partnership can develop.

The following summary applies to the focus ability of the South African TDM industry:

- higher effort in the planning phases is required;
- outsourcing non-core activities will increase value through focused design and manufacturing;
investment in NC technology and the required skills will increase competitive manufacturing; and

- focusing on niche markets will increase product knowledge and experience.

This concludes the analysis of the focus ability.

**Technology base**

The cost distribution for the domestic industry shows a cost allocation below the international average for die concept and design and above the international average for metal cutting. This is indicative of a weak technology base with labour-intensive manufacturing techniques. It is interesting to note that a large percentage of the cost is allocated to NC programming in the domestic industry. Modern CAD and CAM technologies decrease the effort and time required for machine programming as compared to older NC technologies. The South African industry is using older less efficient technologies, as will be shown in the rest of this paragraph.

The cost rate for metal cutting in the SA TDM industry is less than half that of international tool rooms (Figure 4-13). The low cost rate indicates the use of less productive technologies, since allocation of cost for metal cutting will be higher in the event of technologies that are more productive.

![Cost rate metal-cutting [Euro/hour]](image)

*Figure 4-13 CS3 PI: Cost rate metal-cutting*

CS11, Technical Level, depicts a low level of technologies deployed in the domestic TDM industry. Table 4-3 shows the average amount of machining centres for both the domestic and international industries.
South African TDMs are generally smaller than international TDMs (refer to figure 3-3 Representation of international database). This inhibits investment in expensive modern technologies, since the required funds (earnings retained for the purpose of reinvestment) for capital layout of manufacturing technologies is excessive for small tool rooms.

The average NC machines as a percentage of all machines in South African tool rooms is very low compared to the international percentage. Nearly half the machines in international tool rooms are numerically controlled, while only 19% of the machines in the domestic industry are numerically controlled (Figure 4-14).

![Figure 4-14 CS PI Percentage NC machines](image)

The NC rate metal-cutting indicator depicts the machining time on NC machines as a percentage of the total machining time (Figure 4-15). It is generally accepted that NC
machines are more productive than conventional machining and a higher percentage metal cutting is executed on these machines. Utilising this technology puts the tool industry in a more competitive position. South African TDMs are not currently gaining a competitive advantage from NC machines since the technologies deployed in the domestic industry are not sufficient to compete globally.

![NC rate metal-cutting [%]](image)

*Figure 4-15 CS15 PI: NC-rate metal cutting*

![Cost per order [T Euro]](image)

*Figure 4-16 CS17 PI: Cost per order*

Figure 4-16 above, depicting the cost per order performance indicator of CS17, Order Characteristics, is in support of the low technology base deployed in the South African TDM industry. The low value of orders, a fifth of the international industry (Figure 4-16 [53.00/10.41]) is indicative of simple low value-adding tools produced by the South African TDM industry. The low value of orders is the norm for South African manufacturers, as technologies are inadequate for the manufacturing of more complex high-value adding tools and dies.
The domestic TDM industry spends close to the same number of productive hours per day on an order (Figure 4-18), but only produces a quarter of the value (daily order value created, Figure 4-17 \([0.33/1.27]\)). The value created for close to the same effort is very low for South African TDMs. This indicates the low technology base in the South African TDM industry is a contributing factor to the poor value creation.

Amortisation of simple technologies, in conjunction with the low value being created, does not allow for the recovery of enough funds to reinvest in modern technologies. This Sisyphus syndrome hampers development of the South African TDM industry significantly.

The following summary applies to the technology base of the South African TDM industry:

- technologies in the domestic industry are not as advanced as those in developed countries, e.g. Europe, and
the low technology base is a constraint to productive output of the domestic industry.

This concludes the analysis of the technology base.

**Skills**

The percentage cost allocated to personnel is on par with the international industry (Figure 4-18).

![Figure 4-19 CS2 PI: Percentage cost for personnel](image)

More than half of all personnel in South African tool rooms are allocated to metal cutting (Figure 4-20), but the percentage cost allocated to (Figure 4-19) and the cost rate (Figure 4-21) of this phase in the process chain depict a scenario where low-skilled personnel at low wages are using obsolete technologies at a very unproductive rate.

![Figure 4-20 CS2 PI: Percentage personnel in metal cutting](image)
The percentage of employees with an academic qualification is below average for the domestic industry (Figure 4-22). The skills associated with an academic qualification are essential in project management and cost estimation. Highly skilled knowledge is necessary for efficient process planning and resource allocation throughout the production phases.

South Africa experiences a shortage in the number of trained toolmakers (Figure 4-23). The low skills levels reduce competitiveness in tool rooms.
The high number of unskilled workers (see Figure 4-24) results in low productive output at low cost rates. Training incentives across the industry to increase productive output can be an advantage in view of the low costs associated with the South African workforce. The South African TDM industry should view this pool of low-cost labour as a competitive advantage. The available training and skills development incentives in the domestic TDM industry are not sufficient to develop experienced toolmakers from the available pool of unskilled labour. Newly developed incentives to increase skills and to develop toolmakers from this pool can be monitored through future and continuous benchmarks.

The following summary applies to skills levels in the South African TDM industry:
- low-skilled personnel are using obsolete technologies at unproductive rates;
- academic skills of employees are restraining competitiveness in process planning and resource allocation within the industry; and
incentives are required to develop toolmakers for the domestic industry.

This concludes the analysis of the skills levels.

**Efficiency**

The following information pertaining to efficiency of the phases in the process chain is deduced from the analysis procedure as developed in Chapter 3. Table 4-4 below offers an overview of the resource allocation for the South African TDM industry as compared to resource allocation for international TDMs.

*Table 4-4 Resource allocation*

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>PHASE</th>
<th>PERCENTAGE PERSONNEL</th>
<th>COST RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die concept and design</td>
<td>Below</td>
<td>Below</td>
<td></td>
</tr>
<tr>
<td>Process planning</td>
<td>Above</td>
<td>Below</td>
<td></td>
</tr>
<tr>
<td>NC programming</td>
<td>Above</td>
<td>Above</td>
<td></td>
</tr>
<tr>
<td>Metal cutting</td>
<td>Above</td>
<td>Below</td>
<td></td>
</tr>
<tr>
<td>Finishing/Final assembly</td>
<td>Below</td>
<td>Below</td>
<td></td>
</tr>
<tr>
<td>First-off tool</td>
<td>Above</td>
<td>Above</td>
<td></td>
</tr>
</tbody>
</table>

**Die concept and design**

Advantage can be gained through a strong focus on the early phases to reduce costs during physical manufacturing. South African tool rooms allocate resources poorly to this phase with low efficiency throughout the manufacturing process as result.

**Process planning**

A high number of low-cost employee hours are allocated to this phase. It is assumed that low-cost employees do not hold the required skills to conduct process planning and cost estimation efficiently.
NC programming
The percentage of NC machines is far below the standard set by the global industry. NC machining is currently not a core competency for the South African TDM industry. Allocating a high number of personnel hours and high costs to this phase is extremely inefficient.

Metal cutting
A high number of low-cost employees are allocated to metal cutting. The allocation of personnel and costs are in line with the current environment of the domestic TDM industry, since the South African technology base is not advanced (paragraph 4.2.2.3). A high percentage manual machining with low-cost employees is in line with older technology.

Finishing/Final assembly
It is assumed that cost and personnel allocation for finishing and final assembly activities is transferred to metal cutting in the event of labour-intensive metal cutting operations. This explains the low personnel and cost allocation for Finishing and Final Assembly. This is in line with the manufacturing activities of the South African TDM industry.

First-off tool
The scenario experienced for first-off tool trial runs depicts inefficiencies throughout the process chain. Reworking absorbs high costs and labour hours. There are two possibilities for this high resource allocation to first-off tool. Firstly, skills levels throughout the process chain are not sufficient to produce efficiently, and secondly, obsolete technologies do not produce at the required quality levels. Both these possibilities place the domestic industry in a very uncompetitive position.

CS4, Time Utilisation, is in line with expectations. Utilisation for metal cutting is below the international average, as expected, since technologies are not as advanced in the domestic industry as they are in foreign industries.

The NC rate for metal cutting is the time of NC machine usage as percentage of total machine usage time. The ratio NC rate/NC machines in Table 4-5 below shows a higher percentage of utilisation by South African TDMs of their available NC machines at a higher percentage than their international counterparts. The only explanation is that
obsolete technologies are under utilised and that low value-adding metal cutting is done on high-value adding NC machines. Capital is absorbed in high cost assets (NC machines) used for operations that can be done on lower cost assets (conventional machining). This is not efficient utilisation of capital layout for the domestic industry.

Table 4-5 NC machine utilisation

<table>
<thead>
<tr>
<th>KEY PERFORMANCE INDICATOR (AVERAGE)</th>
<th>DOMESTIC TDMS</th>
<th>INTERNATIONAL TDMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC rate for metal cutting</td>
<td>33.12%</td>
<td>62.76%</td>
</tr>
<tr>
<td>Percentage NC machines</td>
<td>18.97%</td>
<td>49.05%</td>
</tr>
<tr>
<td>Ratio: NC rate/NC machines</td>
<td>1.746</td>
<td>1.280</td>
</tr>
</tbody>
</table>

Figure 4-25 below shows that a very low percentage of quotes are converted to orders for domestic TDMs. Manufacturing capabilities are not at competitive standards, and orders will rather be imported from internationally competitive tool rooms (refer to Paragraph 1.3 Figure 1-1 for the trade deficit of automotive tooling).

![Quote (offering) conversion][1]

Figure 4-25 CS 16 PI: Quote (offering) conversion

The percentage of in-due-time orders is on par with the international standard (Figure 4-26), but older technologies with longer lead times for simpler products increase the lead time and reduce the overall competitiveness of the domestic industry. The result is orders lost to imports.
Figure 4-26 CS16 PI: Percentage in-due-time orders

Figure 4-27 below offers valuable insight into efficiency when viewed in conjunction with the focus ability, technology base and skills levels of a tool room or industry. South African tool rooms cannot produce high-value complex tools with a low technology base. It is extremely difficult to escape from this scenario. Not enough returns can be generated from producing low-value adding tools to invest in competitive technologies.

Figure 4-27 CS17 PI: Cost per order
The low technology base in conjunction with low skills levels does not allow South African tool rooms to create a high daily-order value (see Figure 4-28).

Low technology levels, weak focus ability and low skills reduce efficient manufacturing of South African tool rooms. This can be seen in Figure 4-29, showing the number of productive hours spent on an order per day.

Figure 4-30 below offers a good picture of how efficiently personnel are utilising available machining time. The ratio provides a value for the total machining time/time of actual metal cutting. This is a very clumsy portrayal of the information. The reciprocal of the formula (see Table 4-6) gives metal cutting as a percentage of total machine usage time.
The above values indicate inefficient utilisation of available machine time in the domestic TDM industry.

The South African industry does not produce TDM products efficiently enough. The lack of efficient manufacturing lowers global competitiveness significantly. Skills development and investment in modern technologies will increase efficiency of South African tool rooms and the TDM industry in general. Unfortunately, the low-order value created leaves the industry in a catch-22 situation of low value creation with little returns for reinvestment in skills development and technologies.

The following summary applies to the efficiency of the South African TDM industry:

- a low technology base and low skills levels reduce efficiency;
- orders are lost to imports due to inefficient manufacturing;
- equipment, especially NC machines are not utilised efficiently; and
- low-cost orders, as a result of low technologies, have little returns as a result, with no opportunity for investment in modern technologies.

This concludes the analysis of the efficiency.
**Motivation**

Illness figures and accident frequency of the South African TDM industry are superior to the same indicators pertaining to international TDM industries. There are two possibilities for small and easily managed firms in the domestic industry ostensibly experiencing fewer accidents than large well-managed firms. Firstly, employees in smaller firms are managed easily and secondly, accidents in smaller firms are not necessarily reported formally. It is assumed that CS10, motivation of employees, have no significant contribution to the benchmarking analysis.

Figure 4-31 below shows the low labour cost in the South African environment. The domestic industry can gain a competitive advantage from low labour cost, since labour is the single largest expense in tool rooms. The competitive advantage is subject to skills development and empowerment throughout the domestic TDM industry.

![Figure 4-31 CS20 PI: Average hourly wages](image)

The low percentage incentive wages goes against empowering strategies (see Figure 4-32). A negative effect on employee motivation will have poor efficiency and execution of tasks as a result.
The following summary applies to the motivation of the South African TDM industry:

- training and empowerment of employees are required to increase the motivation in the South African TDM work environment; and
- incentive wages are not used to their full advantage

This concludes the analysis of the motivation.

4.2.3 Overview of South African TDM performance

Performance of the South African TDM industry can be summarised according to the investigation as set out in paragraph 4.2.2:

1. The ability of South African TDMs to focus on specific markets and products is not competitive. The diversification of manufacturing, especially for small organisations, reduces productivity and efficiency significantly.

2. Shareholders claim profit with very little reinvestment [Dimitrov, Malherbe 2006]. As a result, technologies become obsolete and development of skills in the labour force is not sufficient. This business practice reduces competitiveness and can eventually eliminate the industry from the global playing field. Profits of individual TDMs in South Africa are too little for any significant investment in modern technologies and that a skills shortage reduces productive output. Experience is necessary to develop and mentor inexperienced employees to the required level of competence.

3. Process planning and cost estimation are not done competitively. There is a lack of highly qualified individuals with tooling experience across the South African TDM industry.
5. CONCLUSIONS AND RECOMMENDATIONS

This section presents recommendations to improve the global competitiveness of the South African TDM industry.

5.1 Capacity Building

The South Africa TDM industry has low capacity and thus returns on investments are low. Capacity is defined here as the ability of TDMs to perform tool making effectively, efficiently and sustainably. The industry will have difficulty absorbing a sudden increase in financial intervention without raising capacity to receive such funding first. The capacity to receive funding can be achieved through collaborative business modelling, where projects receiving funds are benefitting more than one tooling organisation. This model should be developed prior to fund allocation for tool rooms; otherwise the effect will be trivial.

Strategic intervention by Government and collaborative business modelling within the industry will provide a platform to increase capacity from where financial intervention can have a maximised impact on development of the industry.

5.1.1 Strategic Intervention

This study found, from the twelve tool rooms included in the domestic database, the nature of the domestic tooling industry is mainly small enterprises run by family members or sole ownership. Case studies show that remuneration is possibly skewed in the industry [Dimitrov, Malherbe 2006]. A high percentage of retained earnings are paid out as profit-sharing to the initial investors with low investment levels in skills development and modern technologies. The low value creation of TDMs in South Africa often leaves the sole owner with little other choice, but to pay retained earnings out as return on his / her initial investment.

Strategic intervention by Government is essential for the revival of the TDM industry in South Africa. The coherent action plan for this improvement intervention should be coordinated amongst the major TDM consumers, TDM manufacturers and suppliers to the TDM industry. A set of good tool-making practices should be developed. Tool rooms that adhere to these practices should be identified and marketed to major tooling
consumers (automotive and packaging). These major consumers should be benefited through import credits (as in the South African Motor Industry Development Programme (MIDP) or through any other economic activity when they purchase products from the identified toolmakers.

Tool rooms adhering to these good tool-making practices should be able to claim support for investment and development from government funding. These practices should include:
- reinvestment of retained profits;
- development of skills;
- adherence to an approved project-management, cost-estimation and quotation system; and
- following a strategy to increase the focus capability within the tool room.

This benchmarking methodology provided in this report provides performance information of individual concerns, and serves as monitoring and management tool for government incentives and intervention. An understanding of trends in the domestic TDM industry as a whole can be developed and updated from the benchmarking database, while individual concerns gain optimal benefit by knowing their own strengths and weaknesses.

The benchmarking methodology, if used over an extended period, can aid in the restructuring of the South African TDM industry through the following two notions:
- the benchmarking model can be used as a tool for an analysis of competitiveness in the value chain of the automotive industry, to ensure that local content of an acceptable quality can be identified and used in this industry; and
- the benchmarking model can be used as an identifying tool for government incentives and private sector measures for interventions to increase the competitiveness of the industry.

5.1.2 Clustering Tool Rooms

Collaboration amongst tool rooms is necessary to uplift competitiveness of the industry. Three reasons for clustering can be identified:

1. Small enterprises do not have the capacity for investment in the required technologies and skills development. Clustering offers the opportunity to share technologies and training programmes. Benefits for the establishment of
2. The lack of capacity in a single tool room for conducting large commissions forces clients to order from large international tooling organisations. Clustering to share capacity will increase the benefit to large tooling consumers, especially for the automotive and packaging industries.

3. Tool rooms can gain knowledge and experience by focusing on specific processes in cluster formations. Specialisation, in which one commission is sectioned according to capabilities of various tooling organisations, will increase efficiency.

Funding for research into the development of a business model for tool room clusters in South Africa will be the first step towards realising a revival of the industry. The current benchmarking model can be developed as an analysis instrument for the performance of tooling clusters. Monitoring and managing tooling clusters will require information sharing, which can easily be achieved through the application of the benchmarking model.

5.2 Long-Term Financial Support

Long-term sustained financial support for investment in the TDM industry is essential for developing the industry to comply with globally competitive standards. Financial structures can be developed after a sustainable platform for capacity development has been established through strategic intervention and clustering.

Continuous benchmarking of the industry and expansion of a common benchmarking database will provide a dashboard for making macroeconomic decisions, e.g. investment in a smelter for the local industry instead of importing tool steel. The benchmarking model provides comparative information to tool rooms on a microeconomic scale. The comparison of a tool room’s performance on a microeconomic scale to the industry standard allows for development of internal improvement strategies.

Long-term financial investment in the TDM industry can influence all aspects of the manufacturing value chain since tool making is at the heart of component manufacturing. It is, as stated in the introduction, a cross-sectional manufacturing industry. The economic benefit of a well-established tooling industry will touch all spheres of manufacturing with job creation as primary advantage.
5.3 Summary

This thesis developed a benchmarking methodology, based on a model developed by the Laboratory for Machine Tools and Production Engineering (WZL) of the Aachen University of Technology in Germany. The model was adapted to suit the South African industrial environment. The work contained in this thesis is based on a pilot implementation of the adapted model on three South African tooling concerns. The information contained in the benchmarking database pertaining to the domestic TDM and international TDM industries allowed an investigation on the performance of the South African TDM industry as a whole. This thesis presented the analysis of a representative dataset for the South African TDM industry according to the developed analysis procedure and recommendations and conclusions has been drawn from this study. Problem areas were identified with proposed solutions for raising the competitiveness of South Africa’s faltering TDM industry.


http://www.csir.co.za/plsql/ptl0002/PTL0002_PGE038_ARTICLE?ARTICLE_NO=4900141 [18 December 2006]


7. APPENDICES
Appendix A: Data-capturing Questionnaire
### Company Sheet

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Year</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This refers to the year in which the data was recorded. If the time window is more than one year, enter the last year in this space.

<table>
<thead>
<tr>
<th>Currency</th>
<th>Currency Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: South African Rand (ZAR)

Example: R

Exchange Rate at time of data recording: 7.50 ZAR bought 1 Euro on 01/02/2004, therefore I enter 7.50

<table>
<thead>
<tr>
<th>Time Window [years]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: The time window of every question is equal to the time window as specified above, unless otherwise stated.

All monetary values are entered in Thousands (e.g. $34000 will be entered as 34)

The default value of the time window should be 1 year. If, for example, only 6 months' data is available, this data can be entered and the time window set to 0.5 years.
## Process Chain Sheet

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Unit</th>
<th>Die concept &amp; design</th>
<th>Process planning</th>
<th>NC-programming</th>
<th>Metal-cutting</th>
<th>Finishing/ final assembly</th>
<th>First of tool</th>
<th>Other processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>Sum of all internal costs associated with this process (personnel cost, implicit depreciation, implicit interest, cost for overhead, others)</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing depth</td>
<td>Percentage of the work that is done by the company itself, in other words the part that is not outsourced</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of employees</td>
<td>Total number of employees assigned to the process (use decimals)</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of directly productive employees</td>
<td>All employees directly contributing to value added</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum number of employees involved</td>
<td>The maximum number of employees that simultaneously work on this stage at any given moment</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of superiors</td>
<td>Number of superiors with the authority to issue instructions (foremen/ executives)</td>
<td>Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual hours</td>
<td>Total actual hours of personnel employed in the process</td>
<td>hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocated hours</td>
<td>Total hours of personnel employed allocated to specific orders</td>
<td>hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*This excludes any costs of outsourcing. Remember that the time window is the amount of years stipulated on the "Company" sheet.*

*Example: If 4 employees work equally hard on each of the 7 types of processes, then the amount to enter in each space is 4/7 = 0.57*

*This refers to the number of employees (as entered above) minus the number of supervisors, cleaners, receptionists, etc.*

*These hours are calculated over the total duration of the time window*

*Time for specific orders refers to time booked against a specific project*
### Time Sheet

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available time of machine usage</td>
<td>Total amount of available time of all machines</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Actual time of machine usage</td>
<td>Total amount of operating time of all machines (including setup times)</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Actual time of NC-machine usage</td>
<td>Total amount of operating time of all NC-machines (including setup times)</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>NC-programming time in central process planning</td>
<td>Total time accumulated in indirect departments (process planning, NC-programming) for NC-programming (preparation of geometry not included)</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>NC-programming time during machine downtime</td>
<td>Total time accumulated in direct departments (metal-cutting) for NC-programming during machine downtime</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>NC-programming time during machine usage</td>
<td>Total time accumulated in direct departments (metal-cutting) for NC-programming during machine usage</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Machine group</td>
<td>Description</td>
<td>Total number of machines [Number]</td>
<td>Process time [hours]</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------</td>
<td>-----------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>3-axis milling machines</td>
<td>Milling machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-axis milling machines</td>
<td>Milling machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSC milling machines</td>
<td>Milling machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turning machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grinding machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDM sinking machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDM cutting machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All machines (incl. NC-machines)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC-machines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring machines</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Costs Sheet (1)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost for personnel</td>
<td>Labour or salary cost + incidental wage or salary cost (e.g. sickness insurance fund, pension insurance fund, UIF, everything that goes to the taxman, etc.)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Cost for material</td>
<td>Cost for raw-, auxiliary material, operating supplies, tools, etc.</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Cost for external services</td>
<td>Cost for external services for die concept and design, process-planning, NC-programming, extended workbench and purchased dies</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Implicit depreciation</td>
<td>Total depreciation expenses</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Time period of depreciation</td>
<td>Average time period of depreciation (years) for all depreciating items in the company</td>
<td>years</td>
<td></td>
</tr>
<tr>
<td>Implicit interest</td>
<td>Cost for interest of capital employed (capital employed = fixed assets + current assets)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Cost for overhead</td>
<td>Overhead cost incurred within the company and paid partially by the die shop but not incurred within the die shop</td>
<td></td>
<td>T</td>
</tr>
</tbody>
</table>

Remember the time window refers to the time window as specified on the “Company” sheet.

This refers to the total cost of outsourced events.

This refers to the total interest paid to banks, owners, or whoever provided capital.

Overheads can be split into 2 parts: the one part is related to manufacturing, and the other not. This refers to the non-manufacturing-related overhead cost. This cost is automatically partially paid by the manufacturing operations.
## Costs Sheet (2)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital assets</strong></td>
<td>Fixed assets (capital employed in the die shop for machines, IT-systems, buildings etc.) + immaterial property (capital employed in the die shop for securities, licenses, patents, etc.)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Current assets</strong></td>
<td>Assets that are expected to be converted into cash within the next year (includes cash, accounts receivable, raw materials, work-in-process, finished goods, etc.)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Turnover</strong></td>
<td>Turnover in tool and die shop (tools, dies and others)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Turnover of previous period</strong></td>
<td>Turnover in tool and die shop (tools, dies and others) during the previous period</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Costs of previous period</strong></td>
<td>The total sum of all costs incurred during the previous period (as indicated on income statement)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>EDP costs</strong></td>
<td>Electronic Data Processing (EDP) costs include costs for service, utilisation, maintenance, repairs and depreciation of EDP-assets, such as PC’s, IT-networks, software, etc.</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Quality Control</strong></td>
<td>Total cost for quality control tasks in the die shop</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Labor cost</strong></td>
<td>Wage costs for workers in the die shop without incidental wage costs, UIF costs (direct salaries)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Additional labor cost (fringes)</strong></td>
<td>Total fringe benefits paid out to employees, over and above salaries (e.g. 13th cheques, unused leave that is paid out, etc.)</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Detailed design consultation</strong></td>
<td>Costs of external consultation for the detailed design phase of product development</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Concept consultation</strong></td>
<td>Costs of external consultation for the concept phase of product development</td>
<td></td>
<td>T</td>
</tr>
</tbody>
</table>
# Orders Sheet (1)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of enquiries</td>
<td>Number of enquiries received from potential clients (an enquiry comprising several sub-enquiries to be considered a single enquiry)</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of quotes</td>
<td>Number of quotes sent to potential clients (a quote comprising several items to be considered a single quote)</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of orders</td>
<td>Number of orders received from clients (an order comprising several items to be considered a single order)</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of new orders</td>
<td>Total amount of orders for newly planned tools and dies</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of branches</td>
<td>Number of different industries to which offerings were issued</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of main clients</td>
<td>Total number of clients with a percentage of greater than 10% of the total turnover that were served</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of clients</td>
<td>Total number of all clients who were served</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of countries</td>
<td>Total number of all countries served</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of suppliers</td>
<td>Number of suppliers and subcontractors that received orders</td>
<td></td>
<td>Number</td>
</tr>
</tbody>
</table>

Remember that all questions on this sheet pertain to the time window as specified on the "Company" sheet.
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average applied hours per order</td>
<td>Average hourly effort required for the processing of a new order</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Average lead time</td>
<td>Average lead time for a new order (days)</td>
<td></td>
<td>days</td>
</tr>
<tr>
<td>Average lead time for first of tool</td>
<td>Average lead time required for first of tool (referring to the lead time of a new order) (days)</td>
<td></td>
<td>days</td>
</tr>
<tr>
<td>Average order value</td>
<td>Average value of a new order</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Number of alterations</td>
<td>Total number of constructive modifications issued by customers after order commissioning</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Cost for alteration orders</td>
<td>Total costs for constructive modifications issued by customers after order commissioning</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Cost for maintenance orders</td>
<td>Total costs for maintenance orders of tools and dies</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Cost for repair orders</td>
<td>Total costs for repair orders of tools and dies</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Cost for new orders</td>
<td>Total costs for new orders of tools and dies</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Number of in-due-time orders</td>
<td>Total number of orders delivered on time (an order comprising several products to be considered one order)</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of late orders</td>
<td>Total number of orders delivered late (an order comprising several products to be considered one order)</td>
<td></td>
<td>Number</td>
</tr>
</tbody>
</table>

Lead time refers to the time that passes from the day that an order is received, to the day that the order is delivered.

Here, lead time refers to the time that passes from the day that an order is received, to the day that the first of tool is finished.
### Personnel Sheet (1)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of apprentices</td>
<td>Total number of apprentices in the die shop</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of accidents</td>
<td>Number of accidents at work during the time window, that were reported in the official accident statistics</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Employee throughput</td>
<td>Average number of years that an employee works at your company</td>
<td></td>
<td>years</td>
</tr>
<tr>
<td>Number of CAD-employees</td>
<td>Number of direct employees in design working at CAD-workstations</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Time of illness of the salary earners</td>
<td>Cumulative time of illness of salary earners in the die shop recorded in official illness statistics</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Time of illness of the wage earners</td>
<td>Cumulative time of illness of wage earners in the die shop recorded in official illness statistics</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Number of employees with incentive wage</td>
<td>Number of employees receiving incentive wage (employees paid per hour)</td>
<td></td>
<td>Number</td>
</tr>
</tbody>
</table>

*Remember that the time window as specified on the "Company" sheet applies on this sheet.*
## Personnel Sheet (2)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of academics</td>
<td>Total number of employees with technicon or university degree</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of craftsmen</td>
<td>Total number of craftsmen (modelmakers/toolmakers)</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of technicians, foremen, supervisors</td>
<td>Total number of technicians, foremen, and supervisors. These are people with college diplomas, and not university or technikon degrees.</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of unskilled workers</td>
<td>Total number of employees with no specific education</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Wage hours</td>
<td>Number of actual hours performed by wage-earners at the die shop</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Accident related downtime</td>
<td>Down time of employees at the die shop recorded in official accident statistics</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Market research employees</td>
<td>Number of employees in market research &amp; acquisition</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>R&amp;D employees</td>
<td>Number of employees in research and development</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Distribution &amp; Logistics employees</td>
<td>Number of employees in distribution and logistics</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Target capacity wage earners</td>
<td>Cumulative nominal working time (plan capacity) of wage-earners at the tool &amp; die shop</td>
<td></td>
<td>hours</td>
</tr>
<tr>
<td>Sollkapazität Gehaltsempfänger</td>
<td>Kumulierte Nominalarbeitszeit (Plankapazität) der im Betriebsmittelbau beschäftigten Gehaltsempfänger</td>
<td></td>
<td>[h]</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
<td>Value</td>
<td>Unit</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Cost of environmental protection</td>
<td>Costs incurred during waste management, waste prevention, and waste disposal</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Planned turnover Year 1</td>
<td>Planned turnover 1 year ago</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Planned turnover Year 2</td>
<td>Planned turnover 2 years ago</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Planned turnover Year 3</td>
<td>Planned turnover 3 years ago</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Investment expenditures</td>
<td>Investments in fixed assets (machines, IT-systems, other facilities, buildings, etc.) - new investments - replacement investments - improvement investments</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td>Number of CAD-systems</td>
<td>Number of different CAD-systems that are in use</td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Number of NC-Programming systems</td>
<td>Number of different NC-Programming systems that are in use</td>
<td></td>
<td>Number</td>
</tr>
</tbody>
</table>

Here, the "-" sign means "minus"
**Work Area Sheet**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost of work area</strong></td>
<td>Total cost of area used for tool and die making</td>
<td></td>
<td>T</td>
</tr>
<tr>
<td><strong>Size of total work area</strong></td>
<td>Total size of area used for tool and die making (including secondary areas like passages, storing, etc.)</td>
<td></td>
<td>m²</td>
</tr>
<tr>
<td><strong>Size of machining work area</strong></td>
<td>Total size of area used for machining of tool and die components (like cavities, ejector blades, etc.)</td>
<td></td>
<td>m²</td>
</tr>
<tr>
<td><strong>Size of assembly work area</strong></td>
<td>Total size of area used for assembly during tool and die making (including secondary areas like passages, storing, etc.)</td>
<td></td>
<td>m²</td>
</tr>
</tbody>
</table>
# Tool Specifications Sheet

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. tool length</td>
<td>Maximum length of any tool that can be produced</td>
<td></td>
<td>mm</td>
</tr>
<tr>
<td>Max. tool width</td>
<td>Maximum width of any tool that can be produced</td>
<td></td>
<td>mm</td>
</tr>
<tr>
<td>Max. tool height</td>
<td>Maximum height of any tool that can be produced</td>
<td></td>
<td>mm</td>
</tr>
<tr>
<td>Max. tool weight</td>
<td>Maximum weight of any tool that can be produced</td>
<td></td>
<td>tons</td>
</tr>
</tbody>
</table>
Appendix B: Formulas for Performance Indicators
CS1: Cost Distribution 1

Percentage cost (internal) for Die concept and design [%] =
\[
\frac{\text{costs Die concept and design} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

Percentage cost (internal) for Process planning [%] =
\[
\frac{\text{costs Process planning} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

Percentage cost (internal) for NC programming [%] =
\[
\frac{\text{costs NC programming} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

Percentage cost (internal) for metal-cutting [%] =
\[
\frac{\text{costs metal-cutting} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

Percentage cost (internal) for finishing/final assembly [%] =
\[
\frac{\text{costs finishing/final assembly} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

Percentage cost (internal) for fist of tool [%] =
\[
\frac{\text{costs first of tool} \times 100}{\text{costs Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool}}
\]

CS2: Cost Distribution 2

Percentage cost for personnel [%] =
\[
\frac{\text{costs personnel} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

Percentage implicit depreciation [%] =
\[
\frac{\text{implicit depreciation} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]
APPENDIX B

Percentage implicit interest [%] = \[
\frac{\text{implicit interest} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

Percentage cost for external services [%] = \[
\frac{\text{costs external services} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

Percentage cost for material [%] = \[
\frac{\text{costs material} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

Percentage cost for overhead [%] = \[
\frac{\text{costs overhead} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

Percentage cost for other costs [%] = \[
\frac{\text{other costs} \times 100}{\text{costs personnel} + \text{costs material} + \text{costs external services} + \text{implicit depreciation} + \text{implicit interest} + \text{costs overhead} + \text{other costs}}
\]

CS3: Cost Rates

Cost rate Die concept and design [Euro/hour] = \[
\frac{(\text{costs Die concept and design} \times 1000 / \text{exchange rate})}{\text{actual hours Die concept and design}}
\]

Cost rate Process planning [Euro/hour] = \[
\frac{(\text{costs Process planning} \times 1000 / \text{exchange rate})}{\text{actual hours Process planning}}
\]

Cost rate NC programming [Euro/hour] = \[
\frac{(\text{costs NC programming} \times 1000 / \text{exchange rate})}{\text{actual hours NC programming}}
\]

Cost rate metal-cutting [Euro/hour] = \[
\frac{(\text{costs metal-cutting} \times 1000 / \text{exchange rate})}{\text{actual hours metal-cutting}}
\]

Cost rate finishing/final assembly [Euro/hour] = \[
\frac{(\text{costs finishing/final assembly} \times 1000 / \text{exchange rate})}{\text{actual hours finishing/final assembly}}
\]

Cost rate first of tool [Euro/hour] = \[
\frac{(\text{costs first of tool} \times 1000 / \text{exchange rate})}{\text{actual hours first of tool}}
\]
CS4: Time Utilization

Utilization of Die concept and design [%] =
\[
\frac{\text{allocated hours Die concept and design} \times 100}{\text{actual hours Die concept and design}}
\]

Utilization of Process planning [%] =
\[
\frac{\text{allocated hours Process planning} \times 100}{\text{actual hours Process planning}}
\]

Utilization of NC programming [%] =
\[
\frac{\text{allocated hours NC programming} \times 100}{\text{actual hours NC programming}}
\]

Utilization of metal-cutting [%] =
\[
\frac{\text{allocated hours metal-cutting} \times 100}{\text{actual hours metal-cutting}}
\]

Utilization of finishing/final assembly [%] =
\[
\frac{\text{allocated hours finishing/final assembly} \times 100}{\text{actual hours finishing/final assembly}}
\]

Utilization of first of tool [%] =
\[
\frac{\text{allocated hours first of tool} \times 100}{\text{actual hours first of tool}}
\]

Utilization of other [%] =
\[
\frac{\text{allocated hours other} \times 100}{\text{actual hours other}}
\]

CS5: Core Competencies

percentage of Die concept and design incurred in-house [%] = manufacturing depth Die concept and design

percentage of Process planning incurred in-house [%] = manufacturing depth Process planning

percentage of NC programming incurred in-house [%] = manufacturing depth NC programming

percentage of metal-cutting incurred in-house [%] = manufacturing depth metal cutting

percentage of finishing/final assembly incurred in-house [%] = manufacturing depth finishing/final assembly

percentage of first of tool incurred in-house [%] = manufacturing depth first of tool
CS6: Personnel Distribution

Percentage personnel Die concept and design [%] = 
\[
\frac{\text{number of employees Die concept and design} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

Percentage personnel Process planning [%] = 
\[
\frac{\text{number of employees Process planning} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

Percentage personnel NC programming [%] = 
\[
\frac{\text{number of employees NC programming} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

Percentage personnel metal-cutting [%] = 
\[
\frac{\text{number of employees metal cutting} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

Percentage personnel finishing/final assembly [%] = 
\[
\frac{\text{number of employees finishing/final assembly} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

Percentage personnel first of tool [%] = 
\[
\frac{\text{number of employees first of tool} \times 100}{\text{(number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool)}
\]

CS7: Internal / External Cost Distribution

Percentage cost (internal/external) for Die concept and design [%] = 
\[
\frac{\text{costs Die concept and design} / \text{manufacturing depth Die concept and design} \times 100}{(\text{costs Die concept and design} / \text{manufacturing depth Die concept and design}) + (\text{costs Process planning} / \text{manufacturing depth Process planning}) + (\text{costs NC programming} / \text{manufacturing depth NC programming}) + (\text{costs metal-cutting} / \text{manufacturing depth metal-cutting}) + (\text{costs finishing/final assembly} / \text{manufacturing depth finishing/final assembly}) + (\text{costs first of tool} / \text{manufacturing depth first of tool})
\]
**APPENDIX B**

**Percentage cost (internal/external) for Process planning [%] =**
\[
\text{costs Process planning / manufacturing depth Process planning} \times 100 \\
\text{(costs Die concept and design / manufacturing depth Die concept and design) + (costs Process planning / manufacturing depth Process planning) + (costs NC programming / manufacturing depth NC programming) + (costs metal-cutting / manufacturing depth metal-cutting) + (costs finishing/final assembly / manufacturing depth finishing/final assembly) + (costs first of tool / manufacturing depth first of tool)}
\]

**Percentage cost (internal/external) for NC programming [%] =**
\[
\text{costs NC programming / manufacturing depth NC programming} \times 100 \\
\text{(costs Die concept and design / manufacturing depth Die concept and design) + (costs Process planning / manufacturing depth Process planning) + (costs NC programming / manufacturing depth NC programming) + (costs metal-cutting / manufacturing depth metal-cutting) + (costs finishing/final assembly / manufacturing depth finishing/final assembly) + (costs first of tool / manufacturing depth first of tool)}
\]

**Percentage cost (internal/external) for metal-cutting [%] =**
\[
\text{costs metal-cutting / manufacturing depth metal-cutting} \times 100 \\
\text{(costs Die concept and design / manufacturing depth Die concept and design) + (costs Process planning / manufacturing depth Process planning) + (costs NC programming / manufacturing depth NC programming) + (costs metal-cutting / manufacturing depth metal-cutting) + (costs finishing/final assembly / manufacturing depth finishing/final assembly) + (costs first of tool / manufacturing depth first of tool)}
\]

**Percentage cost (internal/external) for finishing/final assembly [%] =**
\[
\text{costs finishing/final assembly / manufacturing depth finishing/final assembly} \times 100 \\
\text{(costs Die concept and design / manufacturing depth Die concept and design) + (costs Process planning / manufacturing depth Process planning) + (costs NC programming / manufacturing depth NC programming) + (costs metal-cutting / manufacturing depth metal-cutting) + (costs finishing/final assembly / manufacturing depth finishing/final assembly) + (costs first of tool / manufacturing depth first of tool)}
\]

**Percentage cost (internal/external) for first of tool [%] =**
\[
\text{costs first of tool / manufacturing depth first of tool} \times 100 \\
\text{(costs Die concept and design / manufacturing depth Die concept and design) + (costs Process planning / manufacturing depth Process planning) + (costs NC programming / manufacturing depth NC programming) + (costs metal-cutting / manufacturing depth metal-cutting) + (costs finishing/final assembly / manufacturing depth finishing/final assembly) + (costs first of tool / manufacturing depth first of tool)}
\]

**CS8: Productivity**

**Productivity [Euro/employee] =**
\[
\frac{(\text{turnover} - \text{cost for material} - \text{cost for external services}) \times 1000}{\text{exchange rate}} \\
\frac{(\text{number of employees Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool} + \text{other processes})}{\text{number of employees Die concept and design} + \text{process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool} + \text{other processes}}
\]
APPENDIX B

Percentage of directly productive employees [%] =
\[
\frac{\text{number of directly productive employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]

Management ratio non-manufacturing departments [Index] =
\[
\frac{\text{number of employees Die concept and design + Process planning + NC programming} - \text{number of superiors Die concept and design + Process planning + NC programming}}{\text{number of superiors Die concept and design + Process planning + NC programming}}
\]

Management ratio manufacturing departments [Index] =
\[
\frac{\text{number of employees metal-cutting + finishing/final assembly + first of tool} - \text{number of superiors metal-cutting + finishing/final assembly + first of tool}}{\text{number of superiors metal-cutting + finishing/final assembly + first of tool}}
\]

CS9: Skills Levels

Employee qualification academic [%] =
\[
\frac{\text{number of academics}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]

Employee qualification craftsman [%] =
\[
\frac{\text{number of craftsmen}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]

Employee qualification technician, foreman, supervisor [%] =
\[
\frac{\text{number of technicians, foremen, supervisors}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]

Employee qualification unskilled worker [%] =
\[
\frac{\text{number of unskilled workers}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]

Apprentice ratio [%] =
\[
\frac{\text{number of apprentices}}{\text{number of employees Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes}} \times 100
\]
CS10: Motivation of Employees

Illness figures of the wage earners [%] =
(time of illness of the wage earners * 100) / target capacity wage earners

Accident frequency [accidents/million hours] =
number of accidents * 1000000
(actual hours Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes)

Accident-related personal delays [%] =
accident related downtime * 100
(actual hours Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes)

CS11: Technical Level

3-axis milling machines [Number] = total number of machines: 3-axis milling machines

5-axis milling machines [Number] = total number of machines: 5-axis milling machines

HSC milling machines [Number] = total number of machines: HSC milling machines

Presses [Number] = total number of machines: presses

Measuring machines [Number] = total number of machines: measuring machines

CS12: Automation1

Manless machine running quota milling [%] =
(manless process time: 3-axis milling machine + 5-axis milling machine + HSC milling machines) * 100
(process time: 3-axis milling machine + 5-axis milling machine + HSC milling machines)

Manless machine running quota grinding [%] =
(manless process time grinding machines * 100) / process time grinding machines

Manless machine running quota sink EDM [%] =
(manless process time EDM sinking machines * 100) / process time EDM sinking machines

Manless machine running quota wire EDM [%] =
(manless process time EDM cutting machines * 100) / process time EDM cutting machines
CS13: Automation2

Multi-machine handling > milling [Number] =
   (average of handled machines per employee: 3-axis milling machines + 5-axis milling machines +
   HSC milling machines) / 3

Multi-machine handling > grinding [Number] =
   average of handled machines per employee: grinding machines

Multi-machine handling > sink EDM [Number] =
   average of handled machines per employee: EDM sinking machines

Multi-machine handling > wire EDM [Number] =
   average of handled machines per employee: EDM cutting machines

CS14: Client and Supplier Base

Number of branches [Number] = number of branches

Number of countries [Number] = number of countries

Number of clients [Number] = number of clients

Number of main clients [Number] = number of main clients

Number of suppliers [Number] = number of suppliers

CS15: NC Technical Level

NC rate metal cutting [%] = (actual time of NC machine usage * 100) / actual time of machine usage

Percentage NC machines [%] =
   (number of NC controlled machines: 3-axis milling machines + 5-axis milling machines + HSC milling machines +
   drilling machines + turning machines + grinding machines + presses + EDM sinking machines + EDM cutting machines +
   other machines) * 100
   total number of machines: 3-axis milling machines + 5-axis milling machines + HSC milling machines +
   drilling machines + turning machines + grinding machines + presses + EDM sinking machines + EDM cutting machines +
   other machines

Percentage NC programming time during central Process planning [%] =
   NC programming time in central Process planning * 100
   NC programming time: in central Process planning + during machine downtime + during machine usage
APPENDIX B

Percentage NC programming time during machine usage [%] = 
NC programming time during machine usage * 100
NC programming time: in central Process planning + during machine downtime + during machine usage

Percentage NC programming time during machine downtime [%] = 
NC programming time during machine downtime * 100
NC programming time: in central Process planning + during machine downtime + during machine usage

Quota NC runtime/programming [Index] =
actual time of NC machine usage
NC programming time: in central Process planning + during machine downtime + during machine usage

CS16: Quotation Characteristics

Quote (offering) conversion [%] = (number of orders * 100) / number of enquiries

Alteration frequency [Index] = number of alterations / number of new orders

Percentage in-due-time orders [%] = (number of in-due-time orders * 100) / number of orders

CS17: Order Characteristics

Cost per order [T Euro] = (cost for new orders / exchange rate) / number of new orders

Daily order value created [T Euro/day] = (average order value / exchange rate) / average lead time

Productivity of order [hours/day] = average applied hours per order / average lead time

CS18: Types of Orders

Order mix cost new order [%] =
cost for new orders * 100
cost for personnel + implicit depreciation + implicit interest + cost for external services + cost for material +
other cost + cost for overhead

Order mix cost alteration [%] =
cost for alteration orders * 100
cost for personnel + implicit depreciation + implicit interest + cost for external services + cost for material +
other cost + cost for overhead

Stellenbosch University Department of Industrial Engineering
Order mix cost maintenance [%] = 
\[
\frac{\text{cost for maintenance orders}}{\text{cost for personnel} + \text{implicit depreciation} + \text{implicit interest} + \text{cost for external services} + \text{cost for material} + \text{other cost} + \text{cost for overhead}} \times 100
\]

Order mix cost repair [%] = 
\[
\frac{\text{cost for repair orders}}{\text{cost for personnel} + \text{implicit depreciation} + \text{implicit interest} + \text{cost for external services} + \text{cost for material} + \text{other cost} + \text{cost for overhead}} \times 100
\]

CS19: Cost and Productivity

Turnover [T Euro/employee] = 
\[
\frac{\text{turnover}}{\text{exchange rate}} \div \text{time window}
\]
\[
= \frac{\text{number of employees: Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool} + \text{other processes}}{\text{turnover}}
\]

Turnover profitability [%] = 
\[
\frac{\text{turnover} - \text{cost for personnel} - \text{implicit depreciation} - \text{cost for external services} - \text{cost for material} - \text{other cost} - \text{cost for overhead}}{\text{turnover}} \times 100
\]

Return on capital employed [%] = 
\[
\frac{\text{turnover} - \text{cost for personnel} - \text{implicit depreciation} - \text{cost for external services} - \text{cost for material} - \text{other cost} - \text{cost for overhead}}{\text{capital assets} + \text{current assets}} \times 100
\]

Capital turnover [%] = \(\frac{\text{turnover} \times 100}{\text{capital assets}}\)

Cost oriented investments [%] = 
\[
\frac{\text{investment expenditures} \times 100}{\text{cost for personnel} + \text{implicit depreciation} + \text{cost for external services} + \text{cost for material} + \text{other cost} + \text{cost for overhead} + \text{implicit interest}}
\]

Cost per employee [Euro/employee] = 
\[
\frac{\left((\text{cost for personnel} + \text{cost for material} + \text{cost for external services} + \text{implicit depreciation} + \text{cost for overhead} + \text{other cost} + \text{cost for overhead} + \text{implicit interest}) \times 1000 / \text{exchange rate}\right)}{\text{time window}}
\]
\[
= \frac{\text{number of employees: Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool} + \text{other processes}}{\text{number of employees: Die concept and design} + \text{Process planning} + \text{NC programming} + \text{metal-cutting} + \text{finishing/final assembly} + \text{first of tool} + \text{other processes}}
\]
CS20: Wages

Average hourly wage [Euro/hour] = \( (\text{labour cost} \times 1000 / \text{exchange rate}) / \text{wage hours} \)

Incidental wage cost [Euro/hour] = \( (\text{additional labour cost (fringes)} \times 1000 / \text{exchange rate}) / \text{wage hours} \)

Utilization personnel [%] =
allocated hours: Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes
actual hours: Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes

Personnel related efficiency of machine capacity [%] = actual time of machine usage / actual hours metal cutting

Capacity of production equipment [%] = \( (\text{actual time of machine usage} \times 100) / \text{available time of machine usage} \)

Percentage employees incentive wage [%] =
\( (\text{number of employees with incentive wage} \times 100) / \text{(number of employees: Die concept and design + Process planning + NC programming + metal-cutting + finishing/final assembly + first of tool + other processes)} \)

CS21: CAD Technical Level

CAD-quota [%] = \( (\text{number of CAD-employees} \times 100) / \text{number of directly productive employees: Die concept and design} \)

Lead time quota first of tool [Index] = average lead time for first of tool / average lead time
Appendix C: Plausibility Checks
Plausibility checks are conducted on the information as presented in the data-capturing questionnaire to ensure the viability of information offered by a tool room and to eliminate incorrect calculations for the benchmarking analysis.

The following plausibility checks ensure that the tool room enters the information as described, per questionnaire sheet, correctly into the data-capturing questionnaire.

**Process Chain**
The following plausibility checks ensure that the number of employees is entered correctly into the data-capturing questionnaire:
- number of directly productive employees (per phase) < number of employees (per phase)
- maximum number of employees involved (per phase) < number of employees (per phase)
- number of superiors (per phase) < number of employees (per phase)

**Time**
The following plausibility checks ensure that the time of machine usage is entered correctly into the data-capturing questionnaire:
- actual time of machine usage < available time of machine usage
- actual time of NC machine usage < actual time of machine usage

**Machines**
The following plausibility check ensures data entered into the data-capturing questionnaire for automated process time of machines cannot be less than the total process time for the same machine group (where a machine group is defined by the activity of that group, i.e. milling).
- manless process time (per machine group) < process time (per machine group)

The following plausibility check ensures data entered for the number of machines handled per employee cannot be more than the total number of machines in the tool room for each machine group.
- average of handled machines per employee (per machine group) < total number of machines (per machine group)
The following plausibility check ensures data entered for the total number of NC machines cannot exceed the total number of machines in the tool room for each machine group.

- number of NC controlled machines (per machine group) < total number of machines (per machine group)

**Costs**

The following plausibility check ensures that all costs incurred by the tool room equates to the sum of all cost categories in the data-capturing questionnaire.

- all costs incurred = cost for personnel + cost for material + cost for external services + depreciation expenses + interest payable + cost for overheads + all other costs

The following plausibility check ensures labour cost is less than the total cost allocation to all personnel in the tool room.

- labour cost < cost for personnel

**Orders**

The following plausibility check ensures the number of enquiries is less than the number of quotes, which is less than the number of orders received by the tool room.

- number of enquiries < number of quotes < number of orders

The following plausibility check ensures that the number of main clients (a client purchasing more than ten percent of a tool room’s production) is less than the total number of clients.

- number of main clients < number of clients

The following plausibility check ensures the total number of orders is the sum of the number in due time orders and the number of late orders.

- number of in due time orders + number of late orders = number of orders

**Personnel**

The following plausibility check ensures that the number of employees with incentive wage is less than the total number of employees in the tool room.

- number of employees with incentive wage < number of personnel

The following plausibility check ensures the number of hierarchical management levels is at least less than or equal to the total number of supervisors.

- hierarchical management levels ≤ total number of superiors (Sheet2 Process Chain)
APPENDIX C

The following plausibility check ensures wage hours are less than the total number of manhours.
- wage hours < total manhours

Work Area
The last plausibility check ensures the size of the work area is the sum of the machining, assembly and trail run work areas.
- size of total work area = size of machining work area + size of assembly work area + size of trial run area
Appendix D: Case study for Tool Room 1
Development of the benchmarking methodology as set out in the main body of this report is based on the pilot implementation of the benchmarking model. The benchmarking model was implemented in three selected tool rooms as part of the DTI’s Sector Specific Assistance Scheme related to the National Tooling Initiative. The project detail is as follow:

**Benchmarking in the South African Tool and Die Manufacturing Industry**

*Applying a Benchmarking Model to evaluate success factors in South African Tool and Die Workshops*

The project “Development of a Benchmarking Model Based on the Aachen University of Technology Model for the South African Tooling Industry” has been carried out by the Global Competitiveness Centre in Engineering (GCC), Department of Industrial Engineering, Stellenbosch University, during the second half of 2005 in execution of US Contract No S000206 (AIDC/SUNTI-DTI-SSAS Project No P000169) for the Automotive Industry Development Centre (AIDC) within the DTI’s Sector Specific Assistance Scheme related to the National Tooling Initiative. The developed model has been pilot implemented in three tool and die workshops, namely RGC Engineering, Wynberg, Johannesburg, TR1, Germiston, and MFA Mould Shop, Uitenhage.

This case study serves as a tool room specific implementation of the benchmarking model.

The calculation of the performance indicators for the tool room under consideration (TR1) is initially analysed according to the following three step process:

- Observing the information in each core statement
- Interpretation of the information
- Recommendations based on the interpretation

Figure 7-1 depicts the logical sequence of initial analysis.
This initial analysis provides the necessary information for the thorough analysis of the tool room according to the analysis procedure as presented in Chapter 3 of this thesis.

The case study is presented in two sections:

- Section 1 – Core statement analysis according to the diagram presented in Figure 3-6
- Section 2 – Analysis procedure according to the methodology as developed in Chapter 3 of this thesis.
7.1 Core Statement Analysis

7.1.1 CS1 Cost Distribution 1

Observation

Effort in the early phases is on average compared to the international TDMs. There is an interesting deviation in the domestic TDMs. TR1 is allocating more effort to die concept and design than their domestic counterparts, but they lack spending in process planning.

High effort (costs) seems to be allocated to trail runs in the domestic industry due to the high average. TR1 is well below average. Very little effort is allocated to trail runs.

<table>
<thead>
<tr>
<th>PERCENTAGE OF TOTAL COST ALLOCATED TO:</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>On Par</td>
<td>Above</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Above</td>
<td>Below</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>On Par</td>
<td>Far Below</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Very Far Below</td>
<td>Below</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>Above</td>
<td>Very Far Below</td>
</tr>
</tbody>
</table>

Interpretation

The high effort for metal-cutting can be contributed to two possible reasons. Firstly, older technologies increase the personnel resources, time and cost of metal-cutting operations. Secondly, an average effort in the early phases will increase the effort required in the manufacturing phases, as compared to the high effort in the early phases and lower effort in manufacturing phases of the international TDMs.
TR1 takes pride in delivering high quality products to their customers. No aluminium is used in TR1’s products. The higher effort, percentage of total cost, allocated to metal-cutting is contributed to two reasons:
- No aluminium is used in TR1’s products and the cutting of tool-steel requires more effort.
- Secondly, the quantity of metal used increases the amount of metal-cutting required to produce the desired tool. A higher amount of metal-cutting will increase the following costs in the organization:
  - material waste
  - labour costs for high quality and lower volume production

Product quality and consistency is an advantage of this strategy. Effort allocated to the finishing and final assembly phase is very low. This might be due to higher effort in metal-cutting operations. First-off tool trail runs are very low, for two reasons. Firstly, the high quality products require very little reworking and secondly, TR1 does conversion in-house as part of the business. Trail runs are done in-house at a lower cost than outsourced trail runs.

**Recommendation**

Enough resources are allocated to the early phases. An internal assessment model needs to be developed that will monitor the efficiency and work conducted to optimize effort in the early phases. It will be useful to develop an outcome based management programme for the early phases in the organization. In this way the die concept and design, process planning and NC programming work can be scheduled and cost for accordingly. Investment strategies in newer technologies and design capabilities which will link directly to machine centres need to be established. The high quality of TR1’s products provides a sound foundation for venturing into specialized tools and dies, provided that an investment strategy for the required technologies can be implemented.

The high quality products of TR1 might use metal in excess. This will increase lead times due to more metal-cutting requirements, and the costs associated with the tools. TR1 could decide to produce high quality specialized tools, but would have to invest more resolutely in modern technologies to produce specialized tools. TR1 should justify the cost of producing high quality conventional tools. An increase in cost is due to higher raw material costs and higher effort for metal-cutting. More effort in metal-cutting can increase lead time as well. It is essential for TR1 to be able to proof to potential clients that these higher costs have cost saving benefits in the utilization of the tools. Monitoring the life cycle through the client of high quality tools is a strategy to obtain information.
which will either justify or not justify the higher expenditure for high quality tools. This can
serve as marketing pitch for the higher cost tools.

It is important to define all the subtasks in the process chain and the costs allocated to
these processes for successful benchmarks in future. The low cost for finishing and final
assembly needs to be re-evaluated, and heat treatment needs to be taken into
consideration. The analyst assumes that heat treatment is outsourced, even though this
is not reflected in the data-capturing questionnaire.

7.1.2 CS2 Cost Distribution 2

Observation

The cost for personnel are very high, compared to the international and domestic TDMs.
There is some cost for depreciation and some, but quite low, cost for interest. Material
costs are extremely high, especially compared to the international TDMs. and allocation
costs (overheads) are average in TR1. No extra costs are allocated to any other aspects
of the business.

Table 7-2 Percentage of Total Cost allocated to Resources

<table>
<thead>
<tr>
<th>PERCENTAGE OF TOTAL COST ALLOCATED TO:</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Implicit Interest</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>External Services</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Material</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Overheads</td>
<td>On Par</td>
<td>On Par</td>
</tr>
<tr>
<td>Other</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>
Figure 7-3 Percentage Costs allocated to Resources
Interpretation

The high cost for personnel can depict a situation where highly skilled employees will produce little value added in terms of their high skills. The time of the skilled employees are used on lower value adding tasks, but the remuneration stays constant. This indicates under utilization of the high skills. Excess capacity in high skills will result in the high cost for personnel.

The high cost for material is due to over-design of TR1’s products. The organization does take pride in producing high quality tools and dies, which uses more material than lower quality products. Does the cost increase of material (cost, waste and cutting) justify competitiveness in producing higher quality products with a longer operational life, if the component consumption environment tends towards shorter product life-cycles with smaller production runs?

Some depreciation and interest shows investment within the organization, but the level of investment is not high enough to sustain competitiveness in the global market.

No outsourcing of any work takes place. All production and supporting functions occur in-house. This will add to the high costs associated with personnel.

Recommendation

Improving employee efficiency and lower personnel costs by increasing value through correct allocation of personnel:

- Identify all the tasks in the organization (within the process chain) to produce a tool.
- Determine the skills required for achieving each task.
- Determine a cost component for each task to be reflected on the quote to client.
- Cost for the skills required to complete the task at hand.
- Allocate personnel accordingly

Any savings that can be brought about in the tool room should be utilized in the investment of newer technologies. TR1 should identify its core competencies and specific industries to provide products to. Appropriate investment in technologies to improve on the competitiveness of core competencies should occur. Any tasks not
adding enough value should be identified, and outsourced to subcontractors that are more competitive in those specific tasks.

The equipment and technologies in TR1 are older technologies, since the depreciation cost is very low. This is not a successful strategy if TR1’s products are high quality complex tools and dies. Marketing to industries should promote high quality tools, but this is inconsistent with the investment strategy. Very little investment in newer technologies is being made to improve the competitiveness. TR1 should focus on its core competencies, invest in specific identified areas, and outsource any work that can be done more competitively by a subcontractor. Die concept and design and NC programming and machining seems to be an area in which TR1 can excel, provided investment in new technologies, capabilities and training are undertaken in these areas. Any low value adding machining and finishing work should be outsourced in order for TR1 to focus on its core competency of complex design and machining for high quality tools.

7.1.3 CS3 Cost Rates

Observation

All cost rates are below average, as compared to international TDMs, except for the NC programming phase, which is far above the highest value in the dataset. The cost rate for die concept and design is above the domestic average, but for process planning it is far below average. The cost rate for metal-cutting is on average, with the cost rates for finishing and final assembly and first-off tool trail runs being below the domestic average.

Interpretation

Personnel costs are higher in Europe than in South Africa. Personnel cost is the greatest cost component in TDMs. Material cost could possibly be higher in Europe as well, since the logistics of supplying material might be more expensive in Europe than in South Africa. These are possible reasons for the higher average cost rates in the international dataset.

The die concept and design and NC programming phases are early phases and their higher cost rates are a good sign of protecting effort in the early phases. Time spent on NC programming is extremely low, compared to the costs for this phase (cost rate: cost allocated / time allocated). Highly skilled design time (from a design engineer) at a high hourly rate might be allocated to lower skilled technical programming of the NC
technologies. This will reduce the programming time, but the personnel cost allocated to NC programming will be higher than expected. The result will be a high cost rate for NC programming. Skills are not allocated efficiently through this strategy.

Table 7-3 Cost Rates

<table>
<thead>
<tr>
<th>COST RATES (EURO / HR)</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>Far Below</td>
<td>Above</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Very Far Below</td>
<td>Very Far Below</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>Very Far Above</td>
<td>Very Far Above</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Far Below</td>
<td>On Par</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>Very Far Below</td>
<td>Very Far Below</td>
</tr>
</tbody>
</table>

The cost rates for the production phases are far below average. Unskilled labour cost in South Africa is fairly low, which means savings can be achieved through lower labour costs. Low levels in employee skills can increase the time to complete an order, which will increase the time spent on each specific phase. This is another cause for the low cost rates in the process chain of TR1. Longer production times at low cost might be very uncompetitive, due to long waiting time from the client.

Recommendation

TR1 needs to invest in technologies to improve the efficiency of die concept and design and process planning. The early phases are well protected by high resource allocation, but very little time allocated, hence the high cost rates. TR1 needs to determine if the expensive personnel skills are allocated efficiently in the early phases.

Technology which will enhance complex machining directly from CAD workstations will be a core competency for TR1’s tool room. The time required for NC programming and the cost for NC programming needs to be re-evaluated. CAD / CAM manufacturing might
be a very successful strategy for TR1 to follow, since the knowledge base for high quality tools exist, and complex cavities can be produced. The effort allocated to process planning needs to be increased.

**Figure 7-4 Cost Rates**
The low cost rates in the machining and finishing phases coincide with a lead time which is above average for the domestic TDM industry and nearly 1/3 of products are not in-due-time. TR1 does produce high quality complex tools and dies, but the tool room might be uncompetitive in simple machining and finishing operations. It should look to finding a suitable contractor to do simple machining operations according a detailed plan, as set out in the process planning phase. The cost, quality and time to completion will become more competitive with this strategy. TR1 can reduce expenditure in standard machining operations, whilst increasing technology levels for complex, high quality design, planning and machining.

The use of better CAD / CAM technologies in die concept and design will reduce material usage, with a reduction in machining times and redundant material costs whilst the quality stays competitive.

7.1.4 CS4 Time Utilization

Observation

Time utilization depicts the accuracy in planning of work through the process chain. Costing of orders and scheduling of resources can be done more efficiently if the indicators for time utilization in the phases of the process chain are close to one (100%).

Time utilization for the early phases in the process chain is all very accurate. Time utilization for the manufacturing and finishing phases is all below the average for both the international and domestic TDMs.

Interpretation

The man hours planned compared to the man hours spent on production phases are below average. This will result in late delivery of orders, and can be costly in scheduling machine usage. Overtime is very expensive and will increase the cost of an order, if it is not taken into consideration when quoting for an order. Metal-cutting is the most time consuming phase in the process chain, and the most effort must be spent on planning correctly for this phase.
Figure 7-5 Utilization of Phases in the Process Chain
Table 7-4 Time Utilization

<table>
<thead>
<tr>
<th>TIME UTILISATION</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Below</td>
<td>Below</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Below</td>
<td>Below</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>On Par</td>
<td>Below</td>
</tr>
<tr>
<td>Other</td>
<td>Far Above</td>
<td>Above</td>
</tr>
</tbody>
</table>

Recommendations

The weak planning strategies for machining and finishing operations are justifying the above mentioned strategies. A core competency of TR1 lies in the early phases of producing a competitive tool. Investment in die concept and design, and especially process planning will increase the competitiveness of the manufacturing phases. Simple manufacturing processes will, in the long run, be uncompetitive in TR1, provided that tools and dies from the tool room are complex and of high quality. These operations should be outsourced while investment in complex machining and high CAD / CAM processes are required.

This strategy will increase the competitiveness by reducing time and costs for machining and finishing, whilst not losing any quality. It will be essential to provide training for correct utilization of new CAD / CAM technologies. Training and development costs are high, especially if its focus is on early phases with high computer skills required. An investment strategy needs to be developed. Aid from tooling associations in the South African market and government intervention in the domestic TDM industry is required, for two reasons:
Firstly, funding will be required to improve the competitiveness of TR1, by focusing on Core Competencies, which is:

- Die concept and design
- Process planning for producing a competitive tool
- High quality complex products
- Newer technologies and training will be the greatest investment components.

Secondly, support will have to be provided in finding manufacturing partners for standard machining operations, with enough advanced tool rooms contracting enough simple machining operation to a tool room for sustainable partnerships.

### 7.1.5 CS5 Core Competencies

**Observation**

The organization does everything in-house. No work is outsourced.

**Table 7-5 Percentage Work Incurred In-house**

<table>
<thead>
<tr>
<th>PERCENTAGE WORK INCURRED IN-HOUSE</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>Above</td>
<td>Above</td>
</tr>
</tbody>
</table>

**Interpretation**

Is it competitive to do everything in-house? Some processes might be more efficiently done by external organisations. Expensive skilled labour is used for low value-adding tasks in the organization. Manufacturing operations might be done at a lower cost, higher quality and in a shorter lead time by external manufacturers with a specialized focus.
Certain early phase and manufacturing operations, requiring skilled labour, can be contracted into TR1, provided that it is a core competency which will receive more effort and resources with future strategies.

![Percentage of die concept and design incurred in-house [%]](image)

![Percentage of process planning incurred in-house [%]](image)

![Percentage of NC-programming incurred in-house [%]](image)

![Percentage of metal-cutting incurred in-house [%]](image)

![Percentage of finishing/final assembly incurred in-house [%]](image)

![Percentage of first-off tool incurred in-house [%]](image)

*Figure 7-6 Percentage Work Incurred In-house*
Recommendation

TR1 needs to decide what their focus will be in future. The most successful strategy appears to be investment in die concept and design phase of complex high quality tools and dies. Process planning should be improved across the organization to effectively utilize standard machining operations of suppliers. Currently all work is done in house.

A skills assessment needs to be done in TR1. The processes which are being done by over skilled employees will have to be outsourced to appropriate suppliers. Skills in TR1 should be used for value adding tasks, appropriate to the skills. This will decrease cost to personnel, free funding for investment and increase competitiveness levels in the TDM industry.

Two problems will arise with outsourcing tasks that are not value adding due to the lack of low cost resources for low cost operations.

- Firstly, changing processes and removing some internal processes through outsourcing will change the work environment and methodology of employees. Resistance to change will be apparent and all employees should be involved in a change programme, should TR1 embark upon a process of focusing on core competencies.

- The second problem will be in developing a relationship with a supplier. Aid from tooling bodies in South Africa and government incentives for reviving the tooling industry should be sought. This will help in developing tool room clusters.

7.1.6 CS6 Personnel Distribution

Observation

The percentage personnel for die concept and design is just below the international and domestic averages. A high percentage personnel is allocated to process panning (higher than the highest value in the international dataset). A very low percentage personnel is allocated to NC programming. The allocation for metal-cutting is higher than the average for both the international and domestic TDMs. The percentage personnel for finishing and final assembly is quite high compared to the domestic TDMs, but far below average for the international TDMs. A reasonable value is assigned to first-off tool trail runs.
It is interesting to note that early phases with lower cost rates require more personnel, and phases with higher cost rates require fewer personnel.

Table 7-6 Percentage Personnel allocated to Phases of the Process Chain

<table>
<thead>
<tr>
<th>PERCENTAGE PERSONNEL ALLOCATED</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>Below</td>
<td>On Par</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>Very Far Below</td>
<td>Very Far Below</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Below</td>
<td>Above</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>Far Above</td>
<td>Below</td>
</tr>
</tbody>
</table>

Interpretation

TR1 spends high efforts in the early phases, especially for process planning. This is indicative of high effort in the early phases.

The very low personnel distribution in combination with the extremely high cost rate for NC programming is depicting a situation in which NC programming uses very little time, but at an extremely high cost. It is important to determine the amount of NC programming produced during the time spent on programming. This is definitely a core competency of TR1, if the value-added of the process justifies the high cost rate at the reduced time.

The high personnel distribution for metal-cutting can partially be attributed to low levels of new technologies in this phase.

High cutting rates due to quality products (using more than the average amount of material) will increase the cutting time and the personnel employed in the metal-cutting
phase. The low cost rate for metal-cutting can be attributed to older technologies that are more labour intensive, utilising the available low cost labour in South Africa.

<table>
<thead>
<tr>
<th>Percentage personnel die concept and design [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage personnel process planning [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage personnel NC programming [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage personnel metal-cutting [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>20.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage personnel finishing/final assembly [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>4.44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage personnel first-off tool [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Min</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0.00</td>
</tr>
</tbody>
</table>

*Figure 7-7 Percentage Personnel Allocated to Phases of the Process Chain*
The personnel distribution of the finishing and final assembly phase is very low. It is possible that the high efforts in the early phases are justification for the low personnel requirements in this phase.

Recommendation

Determine the NC programming requirements and the time to achieve the necessary NC programming. Personnel and costs can then be assigned accordingly, with strategies to improve the technological level of these early phases. Technologies in CAD / CAM manufacturing will increase the competitiveness of TR1.

Collaboration of tool rooms will be required to achieve competitive TDM manufacturing in the domestic industry due to the smaller sizes of the South African TDMs. Standard machining operations should be outsourced, whilst die concept and design and complex cavities, requiring NC machining should be focused upon in TR1. The personnel allocated to the early phases should be higher, with fewer personnel doing machining and finishing work.

Training will be required to improve the skills in the required fields. TR1 will have to train toolmakers in complex, high quality tool production, whilst standard machining operations can be done by a supplier. A training and resource allocation strategy needs to be developed for the next five to ten years.

7.1.7 CS7 Internal / External Cost Distribution

Observation

The value for this indicator will be exactly the same as the cost distribution (internal) through the process chain, since no production or services are outsourced by TR1. It is interesting to note that the changes in the international dataset range between 10% – 20% for the phases in the process chain.
Table 7-7 Percentage Internal / External Cost allocated to Phases of the Process Chain

<table>
<thead>
<tr>
<th>PERCENTAGE INT / EXT COST ALLOCATED</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Die Concept and Design</td>
<td>On Par</td>
<td>Above</td>
</tr>
<tr>
<td>Process Planning</td>
<td>Above</td>
<td>Below</td>
</tr>
<tr>
<td>NC-Programming</td>
<td>On Par</td>
<td>Far Below</td>
</tr>
<tr>
<td>Metal Cutting</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>Finishing / Final Assembly</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>First-Off Tool Trail Run</td>
<td>Above</td>
<td>Very Far Below</td>
</tr>
</tbody>
</table>

Interpretation

No interpretations can be made from small and consistent deviations in the values from the first cost distribution and the internal / external cost distribution throughout the phases of the process chain in the international dataset. The deviations depend on the core competencies of the organizations and will be different for each organization in the dataset. The average values appear to be consistent. TR1 is currently doing everything in-house, which might not be as competitive as outsourcing. Some tasks being done in-house might be delivered at more competitive levels if it is outsourced. TR1 might be extremely competitive in some tasks, which can stay the core competencies of the organization.

South African organizations, in general, are of the opinion that third party work is not trustworthy enough.

Recommendation

TR1 will have to explore outsourcing standard machining operations whilst focusing on die concept and design, process planning and NC machining of complex cavities. Value-adding in the tool room will increase significantly if this strategy could be followed.
Figure 7-8 Percentage Internal / External Costs allocated to Phases of the Process Chain
7.1.8 CS8 Productivity

Observation

Table 7-8 Productivity

<table>
<thead>
<tr>
<th>PRODUCTIVITY</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Below</td>
<td>Above</td>
</tr>
<tr>
<td>Directly Prod Employees</td>
<td>Below</td>
<td>Below</td>
</tr>
<tr>
<td>Man Non-Manufacturing</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Man Manufacturing</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>

Interpretation

The low productivity depicts a scenario where the cost of employees is high in terms of value creation. There are two important aspects about this indicator. The first is that the turnover values in the international dataset might be higher than the average turnover value for the domestic companies due to higher costs and selling prices for European goods and services. This might be reason for a distorted picture when SA companies are benchmarked against European counterparts. Nonetheless, the low Productivity might indicate a low level of new technologies and a high level of labour in the Tool Room. It is possible that cheaper labour in South Africa makes this situation a desirable one, provided that the lower cost of labour will mitigate the lower output value per employee.

The low average percentage of productive employees indicates low value creation per employee. Personnel costs are being lost to non-value adding tasks in TR1, which can be attributed to management and supervisory time.

The observed information with regards to the management ratios shows that TR1 is not a large manufacturing organization, but rather a smaller enterprise where managers and supervisors are also directly involved with the manufacturing of products. The productivity is influenced negatively, if the company is small and manager / supervisor time is allocated to tasks in the company as non-value adding time.
Recommendation

The highest value creation tasks in the organization needs to be identified. Cost to standard low skilled machining are too high and the value creation too low.

This is due to employees conducting high value-adding tasks and low value-adding tasks at the same remuneration rate. Outsourcing of lower value-adding tasks will be necessary whilst concentration on expanding higher value-adding tasks is necessary. Management and supervisory time can be allocated to die concept and design, process planning and automated NC machining. This will increase the productivity of the tool room. A very strong and close relationship with standard machining organizations needs to be established. It is essential for process planning to be conducted in an information management and quality control efficient manner.
A strategic plan which will show the increase in value adding, job creation and improvement in competitiveness will benefit from government support to form tooling clusters. TR1 will have to be on the high skilled, technologically advanced level of the scale. Design work and knowledge management needs to be developed in TR1. Complex high quality machining should be the core focus, while standard machining operations should be outsourced.

7.1.9 CS9 Personnel Structure

Observation

There are no academics in TR1. The percentage employees with a craftsman / tool making qualification are below average. There are no technicians, foremen or supervisors and the percentage unskilled workers are significantly higher than the international average, but below average for the domestic dataset. There are no apprentice employees in the organization’s personnel structure. The values in the personnel structure does not add to 100%. At least a third of the employees are not accounted for.

Table 7-9 Employee Qualification

<table>
<thead>
<tr>
<th>EMPLOYEE QUALIFICATION</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Craftsmen</td>
<td>Far Below</td>
<td>Below</td>
</tr>
<tr>
<td>Supervisory</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Unskilled</td>
<td>Far Above</td>
<td>Below</td>
</tr>
<tr>
<td>Apprentice</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>
The low level of qualified workers in all the indicators is a concern in the tool room. The South African environment does lend itself to the employment of cheap unskilled labour. More craftsmen, technicians and foremen will be required to compete globally. This is not available in the South African environment and should therefore be created through training programs for unskilled workers. Collaboration of tool rooms is required to share skilled knowledge. There are no training programs in place for the organization. This
inhibits the increasing of skill levels in the unskilled sector of personnel. The shortage of academics and skilled craftsmen will constrain development of core competencies in the early phases of tool production.

*Recommendation*

TR1 needs to train appropriate personnel in die concept and design. Cost estimators and project managers will be essential, especially in the event of outsourcing. Liaison with other metal-cutting tool rooms will be essential, with information management and quality control being important aspects of such a venture.

TR1 should invest in a project management and cost estimating position. This position will entail liaison work with tool rooms in potential tooling clusters. Investment in modern design and machining technologies (CAD / CAM) will be essential for TR1. A design engineer is required for optimal utilization of newer technologies. This can be achieved through internal training, or available training programs from vendors of such technologies. The cost for investing in newer technologies is extremely expensive. High quality tools can be achieved with less material usage through using correct design technologies. The cost for investment in design technologies might be offset against the current material costs. Investment from major clients (e.g. the automotive industry or packaging manufacturers) should be sought as well, provided that the cost and time of producing the complex products will undermine imports from technological advanced and emerging markets.

The skill levels of toolmakers will have to increase in order to lift the value-adding of complex machining. This training needs to occur in-house. Subcontractors for standard machining and bench working can employ less skilled employees.

Training programs can be across organizations in the case of collaboration and tooling clusters. Government will have to be pressed by the private manufacturing sector to obtain incentives for correct training. TR1 should play a role in this process.

7.1.10 CS10 Motivation of Employees

*Observation*

The tool room has a below average illness for wage earners. The tool room is not experiencing any accidents.
Table 7-10 Employee Motivation

<table>
<thead>
<tr>
<th>EMPLOYEE MOTIVATION</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness, Wage Earners</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Accident Frequency</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Accident Delays</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>

**Interpretation**

The low value for the illness of wage earners depicts a scenario in which the wage earners are well motivated. This might be due to the high country wide unemployment in the South African environment and not necessarily due to organizational incentives which will raise the productivity of employees. An accident frequency and downtime of 0 proves that the organization is probably small, but also clean and provides a good working environment.
Recommendation

Process planning is essential. Low skilled employees will lose productivity and motivation as soon as the procedure for work, and the understanding of what to do, is not well explained and in a well known process. Focusing on core competencies will provide the opportunity to develop the working environment in such a way to increase employee motivation, and therefore, productivity. A cost estimator / project manager will be essential in achieving this.

TR1 is not a large tool room, and not plagued by absenteeism. But, nonetheless, employee productivity is very low. An increase in productivity will be experienced through outsourcing of low value adding operations, whilst training employees in the higher value adding operations with incentives, are pursued.

7.1.11 CS11 Technical Level

Observation

The organization has six 3-axis milling machines. The rest of the number of machines is 0.

Table 7-11 Number of Machines

<table>
<thead>
<tr>
<th>NUMBER OF MACHINES</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-axis Milling</td>
<td>On Par</td>
<td>Above</td>
</tr>
<tr>
<td>5-axis Milling</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>HSC Milling</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Presses</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Measuring</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>
Interpretation

There is room for expansion in the technical level of the organization. It is important to determine the capabilities required in the phases other than metal-cutting to determine if and what expansion in the technical level is viable. Collaboration in technology will alleviate the financial burden of investing in new technologies. Establishing core competencies and forming tool room clusters will show the specific areas of metal-cutting in which investments should be made.

Figure 7-12 Number of Machines
Recommendation

It is important to assess the CAM capabilities of the current milling machines. It will be very advantageous if integration between design and machining can be achieved with little investment. Newer CAD / CAM design software will have a substantial increase in the efficiency of the machining centres. Higher quality products can be achieved in shorter lead times.

Collaboration of technologies will alleviate the burden of financial investment. It will be competitive if the possibility exists for investing in a five axes milling machine, provided that the larger clients in tool and die consumption becomes a stakeholder in such an investment.

A business plan will have to be developed with contractual agreements on the use and work supplied for such an investment.

Collaboration to the lower spectrum of technological capabilities is just as essential. Standard machining tool rooms need to collaborate with higher technologically advanced tool rooms, such as TR1, to reduce the cost to lower value adding machining.

7.1.12 CS12 Automation 1

Observation

The manless operating time for milling is above average. It is the highest value in the domestic dataset. The percentage of manless processing time for grinding is 0. The percentage of manless processing time for sink EDM is below average and the value for wire EDM is 0.

Interpretation

The manless processing time for milling is showing that the milling operations are performing above average. This is a good sign in terms of the utilization of machine capability. The high rate of metal-cutting in standard tool components for TR1 (the high amount metal in the high quality products of TR1), which will become standard repetition, is justification for the high level of manless processing time for milling operations.
Table 7-12 Percentage Manless Machine Running Time

<table>
<thead>
<tr>
<th>PERCENTAGE MANLESS RUNNING TIME</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Grinding</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Sink EDM</td>
<td>Very Far Below</td>
<td>Very Far Below</td>
</tr>
<tr>
<td>Wire EDM</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>

The 0 value for grinding is a missing data point in the data-capturing questionnaire and the 0 value for wire EDM is due to the organization not owning a wire cutting machine.

The low value, if correct, for sink EDM is indicative of poor set-up times and machine utilization. NC programming will probably occur during machine down time which is a poor NC programming strategy.

**Recommendation**

The above average manless processing time for the milling operations is in accordance of a strategy to increase CAD / CAM manufacturing capabilities of high quality complex cavities. Design capabilities and process planning for knowledge and quality management will increase the value adding operations of the milling machines.

The milling machines should produce the highest value possible according to the capabilities of the machines. Any lower value adding operations should be outsourced to standard machining tool rooms.

The grinding operations are simple low value adding operations. Outsourcing this, whilst focusing on complex high value adding operations will increase the machine utilization and productivity.
7.1.13 CS13 Automation 2

Observation

The number of milling machines handled per employee is the maximum value for both the domestic and international datasets. Two machinists will be required with the six milling machines in operation. The average number of handled machines for grinding is higher than the highest value in the international dataset, but not as high as the highest value for the domestic dataset.

An employee will spend a third of the grinding operation time on one grinding machine. The number of Sink EDM machines handled per employee is average.
Table 7-13 Number of MachinesHandled per Employee

<table>
<thead>
<tr>
<th>NUMBER OF MACHINES HANDLED</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Grinding</td>
<td>Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Sink EDM</td>
<td>On Par</td>
<td>Above</td>
</tr>
<tr>
<td>Wire EDM</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>

Interpretation

It is interesting to note that employee productivity is not as high as the international productivity levels, but the machine handling per employee is slightly above average. This indicates that machines with a lower productive output are used efficiently. This is not competitive enough, since productivity is still not competitive.

The average number of handled machines per employee for grinding is extremely high. This value does not correspond to the amount of manless operating hours for the machine group. The capital investment in older technology grinding machines is redundant, due to one employee handling three machines of which none can be operated without the supervision of the employee.

Recommendation

Investment in automation for complex machining will increase the value of machining operations. TR1 spends too many resources in lower value adding operations, with technologies that might be able to do higher value adding machining. The availability of higher value adding machining operations depends on market requirements, with regards to the complexity, quality, cost and lead time for products. The tool and die consumer industry import these requirements. TR1 will have to establish partnerships with the major consumers in the tooling industry, whilst at the same time forming partnerships with standard machining tool rooms. CAD / CAM manufacturing and
concurrent engineering will be essential throughout an approach to outsource lower value adding operations. The milling machines handled per employee is very high, and this is already a step towards increasing the value adding operations. Investigation into newer technologies is essential to achieve competitive manufacturing, and the integration of newer technologies with the current technologies should be assessed.

The underutilization of grinding equipment is the perfect example of redundant technologies, which should be moved from TR1’s core operations. The efficiency of these operations will be far higher when a tool room specializes in providing standard machining operations. Collaboration with partners in the industry might justify the development of a standard machining tool centre.

*Figure 7-14 Number of Machines Handled per Employee*
7.1.14 CS14 Clients and Supplier Base

Observation

The number of branches (main industries to which the organization is selling) is close to the maximum value for the international dataset, while it is above average for the domestic dataset as well. The number of countries is average for the international dataset and above average for the domestic dataset. The number of clients is far below average for both datasets. The number of main clients is slightly below average. The number of suppliers is far below average for the international dataset and average for the domestic counterparts.

Table 7-14 Clients and Supplier Base

<table>
<thead>
<tr>
<th>NUMBER OF:</th>
<th>INTERNATIONAL</th>
<th>DOMESTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVERAGE</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>Branches</td>
<td>Very Far Above</td>
<td>Above</td>
</tr>
<tr>
<td>Countries</td>
<td>On Par</td>
<td>Above</td>
</tr>
<tr>
<td>Clients</td>
<td>Very Far Below</td>
<td>Very Far Below</td>
</tr>
<tr>
<td>Main Clients</td>
<td>On Par</td>
<td>Below</td>
</tr>
<tr>
<td>Suppliers</td>
<td>Very Far Below</td>
<td>Below</td>
</tr>
</tbody>
</table>

Interpretation

It is interesting to note that the number of branches compared to the number of clients for the international TDMs is in disagreement to the number of branches compared to the number of clients for the domestic TDMs. TR1 service clients from diverse industries, with few clients. Most products will therefore be new, with new knowledge to be created for the product. This is not efficient supply of quality products. The branches in which core competencies lie should be identified and exploited to produce higher quality products with lower effort.
The rest of the indicators are normal, except for the number of suppliers. This is extremely low and not a healthy situation, since improvement in the supply of quality raw materials and supporting functions at competitive prices and in due time cannot be achieved through a preferred supplier system. It seems to be the nature of the domestic market, since supply to tool and die manufacturers is not on the same level as international counterparts.

![Figure 7-15 Client and Supplier Base](image-url)
Recommendation

Supply to diverse clients will become a core competency if TR1 invests in producing high quality complex tools and dies. High information and quality management is required to produce a different product for each client.

Collaborations on the actual manufacturing of tools and dies are required, in combination with investment partnerships in technologies. All suppliers should be identified, and a model for preferred supplier can be established to ensure timely product delivery and lowest cost for best quality. Collaboration with industry players can be essential in achieving efficiencies in the supply of raw materials to the entire industry. TR1 should partner with direct competitors to increase service delivery from suppliers, and to foster the entry of more suppliers to the domestic industry.

7.1.15 CS15 Technical Level / NC Programming

Observation

The NC rate for metal-cutting and the percentage of NC-machines are below average for the international TDMs but above average for the domestic TDMs. All programming takes place during central process planning. The quota for NC-runtime / programming is extremely high.

Interpretation

The NC rate for metal-cutting is very good compared to TR1’s South African counterparts. The below average percentage NC machines are the reason for the lower NC rate compared to the international TDMs. This is indicative of the lower levels of technology in TR1 and the domestic TDMs. TR1 is more technologically advanced in terms of Metal Cutting than the domestic TDMs.

NC programming in central process planning is a good indicator of concurrent engineering principles within TR1. Some time needs to be allocated to NC programming time during machine downtime or during machine usage for the preparation of part geometry.

The high NC runtime / programming quota is indicating a high efficiency in NC metal-cutting compared to time spent on NC programming. The personnel cost and skills utilized in NC programming with the extremely short programming time were discussed earlier in the document.
Table 7-15 NC Technical Level

<table>
<thead>
<tr>
<th>NC TECHNICAL LEVEL</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC rate metal-cutting</td>
<td>Below</td>
<td>Above</td>
</tr>
<tr>
<td>NC machines</td>
<td>Below</td>
<td>Above</td>
</tr>
<tr>
<td>NC programming – central process</td>
<td>Above (100)</td>
<td>Above (100)</td>
</tr>
<tr>
<td>planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC programming – machine usage</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>NC programming – machine downtime</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>NC programming / runtime index</td>
<td>Very Far Above</td>
<td>Far Above</td>
</tr>
</tbody>
</table>

Recommendation

It is essential for the cost of NC machining technology to be recovered by the operation of the machines. TR1 utilizes a high ratio of NC machining to conventional machining. This means that lower complexity machining appropriate for conventional machining are being done on NC machines. The value-adding on the lower complexity machining will not fully recover the cost of NC capabilities. High complexity work with correct die concept and design and process planning will be required to reach the required value adding levels. Outsourcing of machining appropriate for conventional machining and increasing the complexity of current machining will be required.

It will be decidedly important to establish a client relationship to obtain sufficient orders for restructuring the technology levels in TR1. This can only be achieved through collaboration with tooling consumers. Working towards establishing partnerships is essential in the industry.
APPENDIX D

Stellenbosch University Department of Industrial Engineering

NC rate metal-cutting [%]

Percentage NC machines [%]

Percentage NC programming time during central process planning [%]

Percentage NC programming time during machining usage [%]

Percentage NC programming time during machine downtime [%]

quota NC runtime/programming [Index]

Figure 7-16 NC Technical Level
### 7.1.16 CS16 Quotation Characteristics

**Observation**

The offerings conversion is very low compared to both datasets. The alteration frequency is very low which means that alterations to work are very seldom in TR1. The percentage in-due-time orders are just below the average for both datasets.

**Table 7-16 Quotation Characteristics**

<table>
<thead>
<tr>
<th>QUOTATION CHARACTERISTICS</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quota Conversion</td>
<td>Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Alteration Frequency</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>In-Due-Time Orders</td>
<td>On Par</td>
<td>On Par</td>
</tr>
</tbody>
</table>

**Interpretation**

The low number of quotes that turn into orders is due to wrong planning since the percentage in-due-time orders are below average. This can have a negative impact on the goodwill of clients. TR1 produces more expensive tools and dies, due to higher quality. This will increase the lead time. Longer lead times at higher costs might turn prospective clients away.

The low alteration frequency can be ascribed to the high efforts in the early phases. There are not a lot of problems in the process chain. It might be that the organization knows its process chain very well through providing products with the same equipment for some time without continuous investment in new technologies. This will have the advantage of a low alteration frequency, but the core competency of continuous investment in new technologies is not adhered to.

TR1 takes pride in the fact that they do not sell themselves short by promising unreachable lead times in order to procure an order.
Recommendation

Clients enquiring are deterred from TR1 due to the high cost associated with the quality of the products. TR1 need to make offers more attractive. One way to reduce cost is to determine the cost to value adding ratio of tasks. Some machining operations can be done at a lower cost by a tool room that focuses on standard machining operations. Outsourcing to such a tool room will reduce the machining costs. TR1 will have to reduce over design in products as well. Investing in newer technologies for die concept and design and process planning will aid in tool design. Machining and material costs will be reduced through this.

TR1 is in a position to invest in available technologies, since the NC machining capabilities are above average for the domestic industry, but below average for the international industry. Training will be required when investment in newer technologies takes place.
7.1.17 CS17 Order Characteristics

Observation

The cost per order is extremely low compared to the international TDMs, while it is average for the domestic TDMs. The daily order value created is extremely low for the international TDMs and far below the domestic TDMs as well. The productivity of an order is above average for both datasets.

<table>
<thead>
<tr>
<th>ORDER CHARACTERISTICS</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per Order</td>
<td>Very Far Below</td>
<td>On Par</td>
</tr>
<tr>
<td>Daily Value Created</td>
<td>Very Far Below</td>
<td>Below</td>
</tr>
<tr>
<td>Productivity</td>
<td>Above</td>
<td>Above</td>
</tr>
</tbody>
</table>

Interpretation

The low value for new orders can be ascribed to the low complexity of orders. Products with low complexity will earn less in terms of value than more complex products. TR1 will produce a higher amount of simple products with extremely high quality. It is not a segment in the product scope which will have high returns.

The effort to produce quality products of low simplicity will decrease the daily order value created. It is a position in which the domestic TDMs are, due to the low technology levels and the lack of skills in tool making. Lower costs for orders can be advantages to the domestic industry through utilizing older technologies with low operation costs and cheaper labour to produce less complex products at competitive levels.

Very little order value is created per day in TR1. Applied hours provide small returns. Over design of orders at competitive costs will force high levels of applied hours per order with very little return. This is due to over design of simple orders at low cost to the client. The average productivity of orders can be attributed to high efforts in terms of
applied hours. Close to 8 hours per day are spent on orders from procurement to commissioning. The applied work to an order is extremely high compared to the return on the order, since the hours spent per day is fairly high and the lead times are quite long.

The lack in technology and skilled labour attributes to the situation, but over design of simple products are costly, if TR1 are quoting at market related prices, which they will be forced to do by the market.

![Figure 7-18 Order Characteristics](image)

**Cost per order [T Euro]**

<table>
<thead>
<tr>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
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<td>0.00</td>
<td>10.41</td>
<td>24.38</td>
<td>8.16</td>
<td>9.55</td>
</tr>
</tbody>
</table>

**Daily order value created [T Euro/day]**

<table>
<thead>
<tr>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.47</td>
<td>0.17</td>
<td>1.27</td>
<td>0.06</td>
<td>0.33</td>
<td>0.75</td>
<td>0.24</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**Productivity of order [hours/day]**

<table>
<thead>
<tr>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.43</td>
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<td>7.86</td>
<td>3.04</td>
<td>7.86</td>
<td></td>
</tr>
</tbody>
</table>

**Recommendation**

The solution to the problem is outsourcing low complexity work, whilst investing in the technologies, training and techniques for providing high complexity products. The NC machining capability and other technologies in TR1 are currently under utilized due to the low return on simple products.

TR1 should market to its clients and collaborative ventures between long term clients and the tool room needs establishing before investing in technologies. Industries to target are the automotive and packaging industries due to their large market share. It is imperative to understand the requirements of the automotive and packaging industries. A
clear understanding of the cost, quality and lead time needs to be provided by the big consumers. This information can be used to plan technological investment strategies to obtain the required value adding at the right cost in the right time frames at an expected quality.

Training strategies will be required to achieve the value added in producing complex tools and dies.

7.1.18 CS18 Types of Orders

Observation

The value for new orders is higher than 100%, which is not possible and it is extremely high for repair orders. No alteration orders are done by TR1 and the value for maintenance orders is high for the domestic dataset.

<table>
<thead>
<tr>
<th>PERCENTAGE COST FOR ORDERS – MIX</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Orders</td>
<td>Very Far Above</td>
<td>Very Far Above</td>
</tr>
<tr>
<td>Alteration Orders</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Maintenance Orders</td>
<td>Far Below</td>
<td>Above</td>
</tr>
<tr>
<td>Repair Orders</td>
<td>Very Far Above</td>
<td>Very Far Above</td>
</tr>
</tbody>
</table>

Interpretation

The total cost for the organization is R1 302 920.00. Either this value is too low or the values given as cost for orders are too high. The cost for new orders is R3 000 000.00 which is more than twice as high as the value for all costs in the organization. This is a validity problem in the data for TR1. It is interesting to note that TR1 does not do any alteration orders and very little maintenance orders.
**Recommendation**

No Recommendation.

**Order mix cost new order [%]**

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
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<th>SA Avg</th>
<th>SA Max</th>
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</table>

**Order mix cost alteration [%]**

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<th></th>
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<th>Avg</th>
<th>Max</th>
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<th>SA Avg</th>
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<tbody>
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<tr>
<td>8.55</td>
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</tbody>
</table>

**Order mix cost maintenance [%]**

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<th></th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
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</tbody>
</table>

**Order mix cost repair [%]**

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
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<tbody>
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<td></td>
</tr>
</tbody>
</table>

*Figure 7-19 Percentage Cost for Orders - Mix*

**7.1.19 CS19 Cost and Productivity**

**Observation**

It is important to note that in cost for orders statement (previous statement), the information was incorrect. The costs in TR1 are given as too low, which will have the extremely high turnover profitability as result. The return on capital is extremely high in most of the domestic TDMs. TR1’s return on capital follows this trend.
**Table 7-19 Cost and Productivity**

<table>
<thead>
<tr>
<th>COST AND PRODUCTIVITY</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover / employee</td>
<td>Below</td>
<td>Above</td>
</tr>
<tr>
<td>Turnover profitability</td>
<td>Very Far Above</td>
<td>Far Above</td>
</tr>
<tr>
<td>Return on capital</td>
<td>Very Far Above</td>
<td>Far Above</td>
</tr>
<tr>
<td>Capital turnover</td>
<td>Above</td>
<td>Below</td>
</tr>
<tr>
<td>Cost oriented investments</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
<tr>
<td>Cost per employee</td>
<td>Very Far Below</td>
<td>Below</td>
</tr>
</tbody>
</table>

**Interpretation**

Turnover per employee is quite high for the domestic dataset. This is a positive sign of effective work with the current technology levels for the organization.

The high turnover profitability is due to low costs in TR1, which might be ascribed to the fact that the tool room is part of a company that does plastic injection moulding as well. Some of the costs for the tool room are being carried by the plastic injection venture, without correct determination of the actual costs spent in the tool room.

Old technologies with zero or very little accounting value are used to produce products. This will have a high return on capital employed. The low costs and low assets value (especially capital assets) will increase the return on capital employed.

Capital turnover is healthy, if maintenance on older technologies is affordable (maintenance, repair and downtime costs) and if products are simple enough to be produced efficiently by the older technologies. No investments were made, which is not in accordance to the success factor of continuous and consistent investment in modern technologies. The high rate of low skilled employees and no costs for training programmes is reason to the low cost per employee.
### Turnover [T Euro/employee]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22.03</td>
<td>84.54</td>
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<td>131.76</td>
<td>54.15</td>
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</tbody>
</table>

### Turnover profitability [%]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-44.27</td>
<td>10.30</td>
<td>52.43</td>
<td>18.32</td>
<td>24.28</td>
<td>67.60</td>
<td>67.60</td>
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</tr>
</tbody>
</table>

### Return on capital employed [%]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
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</thead>
<tbody>
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<td>50.05</td>
<td>112.59</td>
<td>112.59</td>
<td></td>
</tr>
</tbody>
</table>

### Capital turnover [%]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
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<tbody>
<tr>
<td></td>
<td>48.80</td>
<td>164.57</td>
<td>435.58</td>
<td>24.10</td>
<td>99.68</td>
<td>199.80</td>
<td>199.80</td>
<td></td>
</tr>
</tbody>
</table>

### Cost oriented investments [%]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
<td>10.55</td>
<td>49.32</td>
<td>0.00</td>
<td>24.10</td>
<td>32.62</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

### Cost per employee [T Euro/employee]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.03</td>
<td>94.66</td>
<td>132.89</td>
<td>93.62</td>
<td>23.47</td>
<td>17.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 7-20 Cost and Productivity*


Recommendation

It is extremely important to follow an investment strategy based upon return on capital deployed. This will force the tool room to safely invest continuously in modern technologies. TR1 will not be able to compete with products of global competition under the current lack of investment in modern technologies.

Cost per employee is very low, due to the lack of training programs in TR1. Investment in new technologies will demand cost to training. TR1 should increase their capabilities in producing complex tools and dies, whilst outsourcing any simple manufacturing processes with low value adding.

7.1.20 CS20 Wages

Observation

The average hourly wage is the lowest level for both datasets at approximately R12 / hr.

Table 7-20 Wages

<table>
<thead>
<tr>
<th>WAGES</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hourly wage</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Incidental wage cost</td>
<td>Very Far Below</td>
<td>Far Below</td>
</tr>
<tr>
<td>Utilization personnel</td>
<td>Below</td>
<td>On Par</td>
</tr>
<tr>
<td>Personnel efficiency</td>
<td>Far Above</td>
<td>Far Above</td>
</tr>
<tr>
<td>Capacity of prod eq.</td>
<td>Below</td>
<td>Below</td>
</tr>
<tr>
<td>Incentive wage</td>
<td>Below (0)</td>
<td>Below (0)</td>
</tr>
</tbody>
</table>
Interpretation

It is most probably the case that cost to employees (labour cost) is not correct, since the plastic injection venture of TR1 carries the cost to employees. Correct information will be required for a comparative benchmark with regards to these Core Statements.

The average personnel utilization is due to average planning for orders. Close to 30% value-adding employee time are spent, without there being planned for.

Personnel related efficiency of machine capacity is extremely high. This high value depicts a situation in which set-up and change over times are extremely high. A great amount of metal-cutting time is lost due to inefficient set-up, tool changing and product change over. There are main two reasons:

- low skilled, poorly motivated employees increase time of machine usage not attributed to Metal Cutting and,
- older technologies are not as efficient in set-up and change over as newer technologies.

The capacity of production equipment is below average for both datasets. Old and redundant technologies might be in the workplace, which is available, but are not being used efficiently at all.

No incentive wages are being paid to employees.

Recommendation

A successful strategy will be to train employees; either to increase the personnel related efficiency with the current equipment or to invest in modern technologies that will require training. Training programs can be based on incentives.

A correct wage cost needs to be determined and recovered from the tool room. A cost to company for personnel needs to be budgeted for, which will include incentives and training.
Figure 7-21 Wages
7.1.21 CS21 Technical Level / CAD

*Observation*

CAD quota is below average for the international dataset.

Lead-time quota first-off tool index is below average for both datasets.

*Table 7-21 Technical Level / CAD*

<table>
<thead>
<tr>
<th>TECHNICAL LEVEL / CAD</th>
<th>INTERNATIONAL AVERAGE</th>
<th>DOMESTIC AVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD quota</td>
<td>Below</td>
<td>Below</td>
</tr>
<tr>
<td>Lead time quota (trail)</td>
<td>Below</td>
<td>Far Below</td>
</tr>
</tbody>
</table>

*Interpretation*

Employees in the die concept and design phase are a CAD design employee and the employees involved with relating the initial concept from procurement to the design phase.

The lead time for TR1 is more than the average lead time. The comparatively short lead time for trail runs might be ascribed to the high quality products of TR1.

*Recommendation*

As described in the previous statements of this report, investment in CAD / CAM manufacturing will have to be the future strategy of TR1. A design engineer working on modern technologies will be required for competitiveness in the tool room. A project manager / cost estimator will need to plan outsourcing and costing to clients to reduce low value adding operations, which are currently costing the tool room.

The quality of TR1’s tools are very high, and first-off trail runs takes place in house at a low cost, due to conversion capabilities in house.
## APPENDIX D

**Stellenbosch University Department of Industrial Engineering**

**Figure 7-22 Technical Level / CAD**

### CAD quota [%]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.50</td>
<td>94.45</td>
<td>100.00</td>
<td>72.94</td>
<td>38.57</td>
<td>60.61</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lead time quota first-off tool [Index]

<table>
<thead>
<tr>
<th></th>
<th>I Min</th>
<th>I Avg</th>
<th>I Max</th>
<th>SA Min</th>
<th>SA Avg</th>
<th>SA Max</th>
<th>SA StdDev</th>
<th>TR1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.16</td>
<td>0.82</td>
<td>0.26</td>
<td>0.37</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*Picture courtesy of Stellenbosch University*
7.2 Analysis Procedure for Tool Room1

7.2.1 Summary
This report provides a clear account of TR1’s competitiveness as a tool, die and mould manufacturer (TDM) in the domestic and global industry. TR1’s competitiveness was determined through a benchmarking exercise, as presented in the benchmarking methodology of this thesis. It is essential that the thesis is studied prior to this conclusive analysis. The thesis explains the benchmarking methodology, purpose of the benchmarking exercise, the benchmarking procedure and the analysis technique.

The purpose of this analysis is to provide a conclusive picture of the findings related to the five identified success factors following the general analysis steps: observation, interpretation and recommendation. A diagram for the analysis procedure (AP) of each Success Factor is presented.

Each success factor is dealt with separately as set out in the benchmarking methodology. A hypothesis is stated for each success factor, based upon the productivity performance of TR1. A thesis is presented through systematic analysis of relationships amongst the core statements. The appropriate core statements and indicators are shown in their interaction and internal dependency. Finally, recommendations and improvement areas for each success factor are discussed.

7.2.2 Information for Hypothesis Statement
CS8: Productivity

TR1’s productivity is above average for the domestic dataset, but below average when compared to the international competitors. The percentage employees with directly productive contributions are below average.
CS19: Cost and Productivity

Turnover is slightly above the domestic average, but below the international average. Turnover profitability is far above average, showing that TR1’s profit margin is very high. This adds to the relatively high return on capital indicators, showing that the asset base of TR1 is low, with little investment of excess profit into newer technologies.
7.2.3 Success Factors

**Focus Ability**

**Hypothesis**

The high productivity compared to domestic competitors is a healthy sign for TR1’s competitiveness in the local market. This is indicative of good focus ability in the manufacturing phases of the tool room, with the deployment of relatively modern technologies, compared to the domestic industry. The lower level of productive employees reduces the focus of the tool room, with administrative tasks reducing the value added of the company.

**Interpretation**

The high productivity, which appears to be a healthy position, might be due to the dual environment of TR1. The company produces tools for an in-house conversion plant. Some of the costs in the tool room are carried by the plastic injection moulding department. This lack of costs associated with the tool room will reduce the potential for focusing on the core competencies and the most value adding tasks in the tool room. All tasks are currently done in-house with no outsourcing taking place (CS5). Lower value adding tasks, which can be outsourced, are reducing the competitive advantage of the tool room.
TR1 abstain, as far as possible, from doing any orders other than new orders according to CS18 (This can be assumed, even though the information in the core statement is not correct). Products are not focussed to specific industries, since TR1 supplies to an above average number of industries (CS14), with a very low number of clients. The competitive advantage of expertise in an industry is lost through this diversification.

Recommendation

A focus on high quality tools, dies and moulds will require focused investment in modern technologies. TR1 is currently well situated to focus on early phases through CAD / CAM technologies of complex products. Skills assessment will reduce tasks done by over skilled employees, and can be outsourced to appropriate suppliers. Skills in TR1 should be used for value adding tasks, appropriate to the skills. This will decrease cost to personnel, free funding for investment and increase competitiveness levels in the organization and the local industry as a whole.

Changing processes and removing some internal processes through outsourcing will change the work environment and methodology of employees. Resistance to change will be apparent and all employees should be involved in a change programme, should TR1
embark upon a process of focusing on core competencies. The second problem will be in developing a relationship with a supplier. Aid from tooling bodies in South Africa and government incentives for reviving the tooling industry should be sought. This will help in developing tool room clusters.

Identifying the most value adding industry, in the diversity of current clients, and focusing on this industry will increase knowledge and reduce costs, time to produce a tool and increase quality. Higher levels of competitiveness can then be achieved in the tool room.

**Technology Base**

![Figure 7-27 Technology Base Analysis Procedure](image)

**Hypothesis**

The technology base of TR1 is competitive in the local industry. Investment in modern technologies is required for the achievement of global competitiveness. Skills of all employees in the tool room are not currently sufficient for introducing modern technologies, since the percentage of productive employees are below average. Low investment in modern technologies increased the return on capital, but this is not a
sustainable position, since investment should be consistent and focussed according to a long term strategy for improving tool room competitiveness.

**Interpretation**

The current technologies deployed in the tool room are not sufficient to stay competitive in the global market (CS11). The efficiency of personnel in operating the current technology is competitive (CS12), but newer technologies will require investment in training. The high multi-tasking of employees (CS13) with below average productivity, compared to the international dataset, suggests the utilization of older technologies in the tool room.

The percentage NC machines are high compared to the domestic industry. This can be a strength if TR1 develops a strategy to manufacture high quality complex products.

**Recommendation**

The above average manless processing time for the milling operations is in accordance with a strategy to increase CAD / CAM manufacturing capabilities of high quality complex cavities. Investment in CAD / CAM manufacturing and concurrent engineering will be essential in an approach to outsource lower value adding operations. The milling machines handled per employee is very high, and this is already a step towards increasing the value adding operations. Investigation into newer technologies is essential to achieve competitive manufacturing, and the integration of newer technologies with the current technologies should be assessed.

The milling machines should produce the highest value possible according to the capabilities of the machines. Any lower value adding operations should be outsourced to standard machining tool rooms, according to the focus ability success factor.

Investment in modern technologies is essential to keep the domestic advantage of producing high quality complex products and to increase the advantage to the international market. The high rate for NC Metal Cutting aids in the decision to increase the Technology Base.
Skills

Hypothesis

The high percentage personnel that are not directly productive reduce competitiveness in TR1. The management ratio's shows to a scenario in which TR1 uses high cost labour to do lower value adding tasks. This destroys value, which should be invested in the expansion of the technology base.

Interpretation

A high percentage of personnel are allocated to early phases (CS6), in which skills development will be required if the technology base is expanded (technology base, success factor). A high percentage of personnel are allocated to metal-cutting (CS6), in which the machine efficiency appears to be competitive (technology base). Some of these employees are adding to the percentage personnel that are not directly productive.

TR1 has a very high percentage unskilled labour in the tool room. This is a healthy situation if investment in training takes place (CS9). The low wages in the organization is probably due to the high percentage unskilled labour. This is not a healthy situation, if competitive levels of efficiency are to be reached (please refer to efficiency and motivation of employees).

Recommendation

Unproductive employees in the machining phase should be reduced to as little as possible, since essential value for investment are destroyed by unproductive tasks. Training should be focussed according to the strategies determined for improving the focus ability and increasing the technology base of the tool room.

Skilled employees, who are in a position to increase their knowledge of modern technology, should receive training in CAD / CAM technology, with an expansion of the
technology base, while unskilled labour should receive the required training in current technologies in the tool room.

Low levels of productivity at a low cost to unskilled employees are conducive to a situation in which the technology base will become under utilized. Investment in increasing the skill levels, according to a strategy in conjunction with the focus of the tool room and the expansion of the technology base is essential to use equipment at its full potential.

Training programs should be based on incentives and work performance.

A cost to company for personnel needs to be budgeted for, which will include incentives and training.

*Efficiency*

*Hypothesis*

Efficiency of machines are currently competitive, whilst employees are not currently working to an efficient level, since the amount of employees involved in the tool room without adding productive value is quite high.

*Interpretation*

![Figure 7-29 Efficiency Analysis Procedure](image)

The man hours planned and spent in the production phases are below average (CS4). This will cause orders to be late, and overtime, to reach deadlines, is expensive, which will increase the cost of orders. Metal-cutting is the most time consuming phase and the most effort must be spent on planning correctly for this phase. TR1 are currently producing a high amount of low complexity moulds with high quality (CS17). This segment does not have high returns, compared to complex products of high quality. The applied work to an order is high compared to the return on the orders, since the hours spent per day on producing a product is high and lead times are high as well (CS17). Over design of simple products are costly, if quotes are at market related prices.
The high personnel related efficiency of machine capacity (CS20) shows that 1 hour metal-cutting takes place for every 2.3 hours machine usage. This translates to only 40% machine utilization during machine operating time. This very low rate for metal-cutting is reducing total machining efficiency significantly. Set-up and change over times are very high. There are two reasons for the efficiency: firstly, low skilled, poorly motivated employees increase time of machine usage not attributed to metal-cutting, secondly older technologies are not as efficient in set-up and change over as newer technologies. The low capacity of production equipment is due to old redundant technologies, which is available, but are not being used efficiently at all. NC machining is done competitively when compared to the domestic industry (CS15).

**Recommendation**

A core competency of TR1 lies in the early phases of producing a competitive tool. Investment in die concept and design, and especially process planning will increase the competitiveness of the manufacturing phases. Simple manufacturing processes will, in the long run, be uncompetitive in TR1, provided that tools and dies from the tool room are complex and of high quality. These operations should be outsourced while investment in complex machining and high levels of CAD / CAM processes will be necessary.

Low complexity work should be outsourced, whilst investing in modern technologies, training and techniques for providing high complexity products. A successful strategy is to train employees to increase the personnel related efficiency with the current equipment and to provide the necessary skills when investing in modern technologies.

It is essential for the cost of NC machining technology to be recovered by the operation of the machines. TR1 utilizes a high ratio of NC machining to conventional machining. This means that lower complexity machining appropriate for conventional machining are being done on NC machines. The value adding on the lower complexity machining will not fully recover the cost of NC capabilities. High complexity work with correct die concept and design and process planning will be required to reach the required value adding levels. Outsourcing of machining appropriate for conventional machining and increasing the complexity of current machining will be required.

It will be decidedly important to establish a client relationship to obtain sufficient orders for restructuring the technology levels in TR1. This can only be achieved through
collaboration with tooling consumers. Working towards establishing partnerships is essential in the industry.

**Motivation**

**Hypothesis**

Positions in management and supervision are well motivated and geared towards productivity, whilst the shop floor workers are not motivated. The competitive productivity describes a scenario where work is done at competitive levels, whilst the low percentage productive employees, at a very low labour cost are indicative of poor performance on the floor.

**Interpretation**

Illness figures of wage earners are very low, but this probably due to the lack of employment in South Africa, and the fear of losing work will prevent unmotivated employees to be absent.

Low skilled poorly motivated employees increase time of machine usage attributed to metal-cutting and reduce overall efficiency in the tool room. Low hourly wage to employees is reducing motivation.

**Recommendation**

Employee motivation can be increased through training and correct allocation of personnel to tasks. Performance incentives and investment in training according to
performance levels will also improve the employee motivation in the tool room. Increase in personnel expenditure on the lower skilled levels through performance incentives will increase motivation, which will have a direct contribution to lead time, time to market and further cost reductions.

7.2.4 Conclusion to the Analysis Procedure

TR1 is currently in an ideal position to increase its technology base to improve total efficiency and the complexity of products. Training and incentives raise the competencies levels and motivation of employees on the shop floor will be required to increase the competitiveness of the tool room.

Focussing on specific industries that requires complex high quality products is essential in becoming a global player. Outsourcing of non core competencies requires collaboration through the development of tool room clusters in the industry. Collaboration in the investment of modern technologies, e.g. five axes milling or high speed cutting, should be investigated as well. CAD / CAM abilities are important in the development of tool room clusters through collaboration of information.

TR1 needs to develop a strategic plan for future investments and focus of the organization. This document provides a clear understanding of TR1’s current position and proposes a future position for the tool room, with appropriate change suggestions.

TR1 should develop a change programme that can be monitored through annual benchmarks. Tool rooms in geographical vicinity of TR1 should be requested to join future benchmarks. Collaboration initiatives can be identified, and all parties in the tooling industry can benefit.

Information for the next benchmarking exercise should be gathered early enough, to have results as soon as possible.