

Abstracts

CHANG, WOON. Analysis of US Technical and Industrial Textile Industry. (Under the direction of Peter Kilduff.)

The production, distribution and consumption of technical and industrial textiles are a large economic activity. However, the scope of this activity, in terms of products, processes and markets is not well defined or measured. Therefore, the size, importance and development pattern of this 'sector' is not well understood.

This difficulty is compounded by the fragmented availability of information on these in official US statistics. The statistical definitions that are used to measure the textile industry are based on traditional classifications. Many individual technical and industrial products are not specifically identified in official data but are typically classified according to fiber, yarn content and process.

In addition, the diversification of technical and industrial products and applications over the years has both expanded and blurred the traditional boundaries of the sector. There are overlaps with other materials sectors, including metal, plastics, minerals and ceramics, foam etc - all substrates used singly or in combinations as engineered materials. Compounding this problem, many final products pass through multiple levels of processing and, during the course of this, often pass to (or originate within) companies in other industries. In these supply chains, many textile suppliers are often unaware of the array of second-tier customers and applications for their products.

Related to the problem of definition, is the inadequacy of the terminology that is used to describe technical and industrial textiles. Historically, they have been described simply as industrial textiles. However, the broad and growing range of applications have led to recognition of the inadequacy of this term in describing textiles used in agriculture, construction and medical applications, among others.

Therefore, the aim of this thesis is to provide a clearer definition and measure of the industrial and technical textile sector in the US in terms of its products, activities and markets. It will also provide an overview of industry development patterns, business drivers and supply chain characteristics.

The research has involved a review of published resources, including academic and trade journals, research texts, and statistical publications by government agencies and industry associations. The approach taken has been to evaluate definitions, terminology and measures used to describe and quantify technical textiles in order to develop a more integrated perspective and an assessment of how it is defined and documented.

**ANALYSIS OF US TECHNICAL AND INDUSTRIAL TEXTILE
INDUSTRY**

by
WOON CHANG

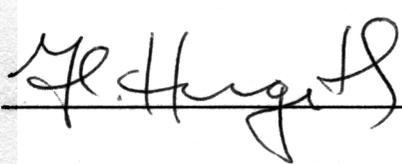
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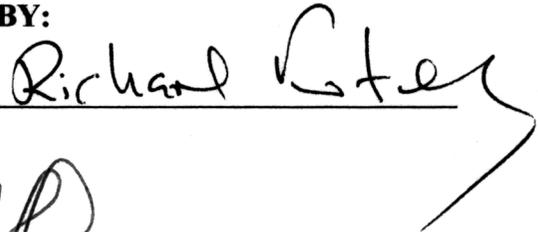
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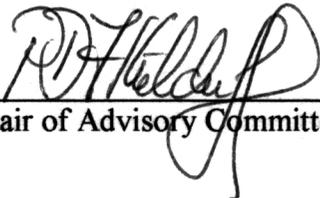
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Biography

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1. INTRODUCTION

1.1 Background

Although they are associated with the growth of synthetics and the resulting expansion of technical products and end-use applications, technical textiles have always been important. It has been with the growth of international competition in apparel and household textile products that has resulted in migration of production and downsizing among the mainstream textile industries within the industrialized nations that technical and industrial textiles have assumed greater importance as alternative markets less exposed to international competition. This perception has been reinforced by a wave of technological innovation over the last few years that is advancing process and product technology and widening the application of textile products even further.

The use of textiles for purposes other than clothing, household textiles and floor coverings is not a new phenomenon. Products such as ropes and twine; wiping and polishing cloths; candlewicks, lints; awnings; sail cloths; nets; sacks and bags; all have long histories that stretch back in some cases more than three millennia. Others such as industrial thread; industrial cloth, uniforms; medical bandaging, and bookbindings are of more recent vintage but stretch back hundreds of years. Even geotextiles are not a phenomenon of the last few decades. In Roman times, woven fabrics and meshes were used to stabilize the marshy ground for road building. In modern times, canvas cloth used in sail ships helped to found the new world and hemp canvas made it possible to explore the western side of the US. Jeans were originally work garments using canvas and then denim cloth that was used to make sailors clothing. In early cars, textiles were used in ragtops and seat cushions.^{1 2}

With the development of synthetic fibers, the end-uses for technical textiles expanded. The new fibers rapidly outgrew and, in many instances, replaced natural fibers, and also opened up new applications in construction (geotextiles) buildings (insulation) agriculture (crop protection), and in engineering (composite materials), among others. Today, technical and industrial textiles have become an increasingly

important component of textile manufacturing in the US, as traditional textile manufacturing relocates offshore.

According to David Rigby³, world-wide consumption of technical textiles in 2000 was 36.8 billion pounds. As estimates by Fiber Organon (July 2001)⁴ put world fiber output at 133 billion pounds in 2000, this represents approximately 28% of world fiber consumption.

For the US, Fiber Organon estimates put fiber consumption in technical end-uses at 4.3 billion pounds in 2000, or 25% of a total fiber consumption of 17.1 billion pounds (Fiber Organon July 2001). The total value of shipments by the US textile industry in 2000 was \$53.1 billion. Using volume share as a proxy for value share, this would put the value of technical textiles at around \$13.3 billion. Given the low unit value of many technical textiles, however, this perhaps exaggerates the size of the segment in dollar terms.⁵

1.2 The research issue

The production, distribution and consumption of technical and industrial textiles are a large economic activity. However, the scope of this activity, in terms of products, processes and markets is not well defined or measured. Therefore, the size, importance and development pattern of this 'sector' is not well understood.

The scope and structure of technical and industrial textile activities and markets is not well defined. In part, this is because a significant proportion of textile manufacturers either produce both consumer and non-consumer textiles, or have diversified from the former to the latter. Thus, a discrete technical and industrial textile sector is not easy to discern.

This difficulty is compounded by the fragmented availability of information on these in official US statistics. The statistical definitions that are used to measure the textile industry are based on traditional classifications, according to one or a combination of fiber (cotton), product (broadwoven fabrics) or process-based (textile finishing) criteria. Many individual technical and industrial products are not

specifically identified in official data but are typically classified according to fiber, yarn content and process.

In addition, the diversification of technical and industrial products and applications over the years has both expanded and blurred the traditional boundaries of the sector. There are overlaps with other materials sectors, including metal, plastics, minerals and ceramics, foam etc - all substrates used singly or in combinations as engineered materials. Compounding this problem, many final products pass through multiple levels of processing and, during the course of this, often pass to (or originate within) companies in other industries, e.g. medical device companies, equipment manufacturers, automotive manufacturers. In these supply chains, many textile suppliers are often unaware of the array of second-tier customers and applications for their products.

Related to the problem of definition, is the inadequacy of the terminology that is used to describe technical and industrial textiles. Historically, they have been described simply as industrial textiles. However, the broad and growing range of applications have led to recognition of the inadequacy of this term in describing textiles used in agriculture, construction and medical applications, among others. The term, technical textiles, has become widely used in Europe and Asia. However, precisely what this embraces is also unclear, though there are a number of widely-accepted classifications. For convenience and consistency, this thesis uses the combined terms, technical and industrial textiles.

1.3 Aims and Objectives

The aim of this work is to provide a clearer definition and measure of the industrial/ technical textile sector in the US in terms of its products, activities and markets. It will also provide an overview of industry development patterns, business drivers and supply chain characteristics.

Specific objectives are to:

- define the sector in terms of products, activities and markets, including major components/ sub-sectors.

- assess the size of the industry and identify patterns of growth in output, international trade and consumption
- assess the structure of the industry in terms of products and kinds of firms that comprise the industry
- examine the drivers of industry development and of the characteristics of technical textile supply chains, and to consider how these differ from consumer textiles.

1.4 Methodology

The research has involved a review of published resources, including academic and trade journals, research texts, and statistical publications by government agencies and industry associations. The approach taken has been to evaluate definitions, terminology and measures used to describe and quantify technical textiles in order to develop a more integrated perspective and an assessment of how it is defined and documented.

1.5 Thesis structure

Section two reviews the definition of technical and industrial textile products, activities and markets. Section three examines trends in output, consumption and trade in technical and industrial textiles. Section four provides an analysis of industry structure and supply chain characteristics and examines the drivers behind the development of the sector. Finally, section five discusses and concludes the findings.

2. Defining Technical and Industrial Textiles

2.1 Terminology

Until comparatively recently, industrial textiles was the accepted term used to describe products that were used in non-consumer applications. However, over the last 25 years, the term, technical textiles, has become increasingly accepted, in the former's place. This has largely been in recognition of the inadequacy of 'industrial' as an adjective to describe the growing array of product applications unrelated to industry, such as agricultural and medical products. Besides being more of an embracing term, the use of technical reflects that a common aspect of non-consumer textiles is that they are primarily designed for technical performance rather than aesthetics. However, this in itself has flaws, in that household wiping cloths are similarly designed for technical performance, while office furnishings incorporate aesthetics into their designs.

Industrial textiles, as a term, has become increasingly (though by no means universally) confined to the description of those products that are used in industrial components or processes. This is discussed further below.

In addition there are other terms that are used loosely or more formally to describe technical textile products or markets. These include high-tech textiles, high-performance textiles and mechanical fabric.² The institutional market for furnishings is often referred to as the contract market.

It is worth comparing textile terminology with that in the management literature. For many years, 'industrial marketing' has been the common lingua franca for selling to business customers other than consumer product distributors. Kotler⁶ notes three types of business markets for products. These are industrial, reseller and government markets. He identifies industrial markets as comprising "individuals and organizations that acquire goods and services to use in the production of other products or services that are sold, rented or supplied to others". He notes that the major industrial markets are in "agriculture, forestry and fisheries; mining; manufacturing; construction; transportation; communication; public utilities;

banking, finance and insurance; and services”. (Kotler, *Marketing Management*, 1991, p196-197) Kotler defines reseller markets as those in which “companies acquire goods to resell at a profit”, while government markets are those in which government agencies “acquire products and services to execute mandated government functions”. In the same text, Kotler defines consumer markets, as comprising those “individuals and households that buy or acquire goods and services for personal consumption” (Kotler, *Marketing Management*, 1991, p162)

With regard to a definition of industrial products, Evans and Berman (*Marketing*, 1997, p37)⁷ define industrial products as "goods and services purchased for use in the production of other goods or services, in the operation of business or for resale to other consumers. Kotler classifies these as comprising materials and parts, capital items and supplies and services. (Kotler, *Marketing Management*, 1991, p434) With the growth of electronic commerce business-to-business marketing and business-to-government marketing have become the more widely-used terms to describe non-consumer marketing.⁸

2.2 Established definitions for technical and industrial textiles

Traditionally, textile products have been classified under three broad end-use headings, namely apparel, home furnishings and industrial textiles. This classification has given rise to identification of home furnishings and industrial textiles as distinct entities, separate from apparel-related textiles. However, while the rationale behind this basic disaggregation has considerable benefits of simplicity for understanding the broad division of textile end-uses, when defining coherent industry segments and in identifying a boundary between consumer and technical and industrial textiles, this distinction owes more to convenience than it does to business realities. The common thread that binds the disparate activities under each division is more tenuous than the strong economic, organizational and technological factors that underpin coherent industries and markets, such as autos, for example. Each of the three divisions embraces activities that are widely divergent in character and which see little in common with other components. This is true in apparel fabrics, where wool textile companies consider themselves to be part of a different industry to cotton textile companies, in home furnishings, where carpet manufacturers see little in common

with towel-makers; and in technical textiles, where nonwovens producers do not see themselves as having much in common with netting manufacturers.

It is useful to review popular definitions of technical and industrial textiles.

Over the years the definition of industrial or technical textiles has evolved to reflect changing perceptions of these activities. The ‘*Callaway Textile Dictionary*’⁹ of 1947 (p.186) defines industrial fabrics as comprising “*a great variety of fabrics, mainly of cotton, which are used in different mechanical processes as filtering, or which are treated or processed so as to become part of other products, as artificial leather or oilcloth.*”

‘*The Modern Textile Dictionary*’¹⁰ of 1963 (p.481) appears to borrow from the ‘*Callaway Textile dictionary*’ in describing industrial fabrics as comprising “*a wide variety of fabrics, chiefly cotton, used in various mechanical processes or which, in turn, are processed or treated in order to become part of another product. Some fabrics of this type include print cloth, duck of all types, sheeting, osnaburg, filter twill, chain cloth, press cloth, jean, drill, twill, and broken twill cotton fabric, sateen, moleskin, multiple fabric, leno- or doup-woven fabric, terry, airplane cloth, balloon fabric, typewriter ribbon fabric.*”

Svedova (*Industrial Textiles*, New York, 1990, p13)¹¹ defines industrial textiles as “*products designed for use in industrial and other sectors of the national economy, or textiles used as a component in the manufacture of materials of non-textile character*”.

More recent definitions tend to differentiate between technical and industrial textiles. The Textile Institute’s publication, ‘*Textile Terms and Definitions*’ (p.340, 1995)¹², describes technical textiles as those “*textile materials and products intended for end-uses other than non-protective clothing, household furnishing and floorcovering, where the fabric or fibrous component is selected principally but not exclusively for its performance and properties as opposed to its aesthetic or decorative characteristics.*”

In the same publication (p.170, 1995) industrial textiles are defined as “*a category of technical textiles used either as part of an industrial process or incorporated into final products*”.

'Fairchild's Dictionary of Textiles' (p.285, 1996)¹³ notes that industrial fabrics is a broad term for “fabrics made of any fiber(s), which is marketed for non-apparel or non-decorative uses.”

The same publication (p.657, 1996) states that technical textiles are “textile product used primarily for its functional characteristic, particularly in high-tech end use.”

According to *Wellington Sears handbook of industrial textiles* p.3 1995)², “Industrial textiles are specially designed and engineered structures that are used in products, processes or services of mostly non-textile industries.”

The same publication notes that there are three basic functions that industrial textiles perform:

- As a component part of another product that directly contributes to the strength, performance and other properties of that product, e.g., tire cord fabric in tires.
- As a tool used in a process to manufacture another product, e.g., filtration textiles in food production, and paper machine clothing in paper manufacturing
- As a product that can be used alone to perform one or several specific functions, e.g., coated fabrics to cover stadiums, a bandage fabric.

2.3 Scope of Technical Textiles

Perhaps the most difficult aspect of understanding technical textiles relates to defining its scope in terms of process stages, products and end-use markets.

2.3.1 Process scope

Establishing the scope of the industry in process terms is relatively straightforward, though there is some confusion over what constitutes a textile activity as a result of the blurring of boundaries between textile and non-textile operations.

The word, *textile*, is derived from the Latin verb *texere*, meaning “to weave.” Originally, textile referred only to woven fabrics and specifically excluded knitted cloth, lace, netting, felt, braid, and cord. Today, in common usage and in government-based definitions textile has also come to embrace yarn manufacture, all forms of fabric manufacture, including knitting, bonding, laminating, felting, or other processes, the dyeing and finishing of yarns and fabrics; and the assembly of textile products where linked to fabric formation, such as knitwear and home textiles.¹⁴

At the upstream boundary of the textile industry, some man-made fibers are specifically engineered for technical applications in textiles. Clearly, fibers not part of the textile industry. Rather, they are raw materials that are manipulated to form textile substrates such as (but not exclusively) yarns and fabrics. However, continuous fibers extruded as high tenacity filament yarns might be perceived as textile products insofar as they comprise individual filaments that are manipulated by being grouped together and twisted to form a yarn. However, most filament man-made fiber production is carried out by specialized man-made fiber companies, which have traditionally been the offspring of larger diversified chemical groups. Therefore, fibers, whether in staple, tow or filament form, are product typically attributed to the fiber industry. Nevertheless, some textile companies extrude their own fiber, including texturizers, carpet manufacturers, and some technical textile manufacturers. Similarly, jute fibers, which are almost exclusively used in technical textile applications, are part of the agricultural sector.

On the downstream boundary of the industry, activities that process yarn and fabric substrates in order to apply finishes are typically characterized as textile operations. However, companies that also manipulate textile substrates into finished products such as sails; awnings and flags and banners are also classified as textile operations (see Appendix B). These are often classified as belonging to a specific end product 'industry', such as the awnings industry, the banners and flags industry. (See Table 2.1)

[Table 2.1] The Industrial Fabrics Association International (IFAI) Divisions

Source: The Industrial Fabrics Association International (IFAI)¹⁵

2.3.2 Product Scope

With regard to the product scope of the technical textile industry, many classifications combine both product and end use bases to describe them.

An early definition is provided by Linton (*The Modern Textile Dictionary*, p.479-482, 1963)¹⁰, who identifies the woven fabrics that are used in ‘industrial and mechanical’ applications. These are shown in Table 2.2.

[Table 2.2] Woven fabrics used in technical and industrial applications in 1963

Army duck	Drills	Napped fabrics
Awning stripe	Enameling duck	Osnaburgs
Balloon fabrics	Gabardine	Print cloth
Bedford cord	Herringbone	Sateens
Belting duck	Hose duck	Sheeting
Bootleg duck	Khakis	Suede
Chafer fabric	Laundry nets and tubing	Tire fabrics
Chain cloth	Lawn cloths	Toweling
Crash	Leno or doup fabrics	Twills
Denim	Moleskins	Upholstery fabric
Drapery fabrics	Jean	Wool fabric

Source: The Modern Textile Dictionary¹⁰

Svedova (*Industrial Textiles - Textile science and technology*, v.9., p.18-26, 1990)¹¹ introduced the classification of technical and industrial textiles on the basis of the main products group and applications. (See Table 2.3)

[Table 2.3] Classification of technical and industrial textiles on the basis of the main product groups and applications

<ul style="list-style-type: none"> A. Canvas <ul style="list-style-type: none"> i. Agriculture ii. Civil engineering iii. Industries iv. Transportation v. Forestry vi. Health service vii. Physical recreation viii. Culture B. Filter Cloth <ul style="list-style-type: none"> i. Chemical and pharmaceutical industries ii. Food stuffing industries iii. Ceramic manufacturing iv. Paper industry v. Cement works vi. Mines and metallurgical works vii. Mineral oil refineries viii. Engineering industry and other C. Textile for the rubber and plastic industry – Rubberized and belting ducks for heavy-duty conveyor belts <ul style="list-style-type: none"> i. Mines ii. Agriculture iii. Civil engineering iv. Industrial sector and other <ul style="list-style-type: none"> Tire cord – Modern automobile industry Backing fabrics D. Industrial textile for the leather industry – the leather and shoemaking industry E. Geotextiles F. Packing materials (Coverstock) G. Cordage H. Belts, webbings and hoses I. Various other industrial textiles

Source: Industrial Textiles¹¹

According to the Fiber Economics Bureau, industrial uses for fibers in the US are divided into 24 categories, as shown in Table 2.4.

[Table 2.4] Industrial Textile Products

Category	Products
Transportation fabric Upholstery and Auto Seat Covers	Auto seat upholstery & slipcovers, sidewall, headlining and sheeting
Hose	Wrapped, knitted, braided and woven products.
Belts	Rubber and non-rubber mechanical belting. Flat conveyor & transmission belts
Chafer & Other Tire	Tire cord & tire cord fabric, chafer and other tire components inc. flippers, liners, bead wrap & breaker strips.
Rope, Cordage & Clothesline	Hawsers, baler, harvest twine, clothesline, tying twine, fishnets, seines & netting twine.
Substrate Fabrics	Woven, knit and nonwoven fabrics used as a substrate for flocking, fine gauge tufting and vinyl, rubber or urethane coating, lamination or impregnation.
Construction Fabrics	Broad woven, nonwoven or spunbonded fabrics, except upholstery and narrow fabrics, used in the construction of automotive seating, upholstered furniture, box springs and mattresses.
Agricultural Cloth	Poultry, shade cloth and commodity covers including coated fabric. Soil erosion and stabilization cloth are under Civil Engineering Uses.
Luggage, Handbags & Other Soft Goods	Only uncoated types. Examples of "soft goods" include military backpacks, athletic backpacks, wallets, briefcases and other soft-sided containers.
Civil Engineering	Paving, soil erosion and stabilization cloth, drainage applications, roofing and other construction industry materials.
Tents, Tarpaulins, Etc.	Uncoated items, such as parachutes, deceleration chutes, tow targets and awnings, beach, garden and tractor umbrellas.
Other Stuffing	Non-engineered fiber and needle batts for filling uses.
Narrow fabrics	Woven labels, industrial webbing, shoelaces, tapes (Venetian blinds & industrial), transportation seat belts, auto wind lace, channeling & trim, outdoor furniture webs and zipper tapes
Medical, surgical & sanitary	Bandages, gauzes, adhesive tapes & plasters, sanitary napkins & tampons, cotton diapers, rayon disposable diapers, surgical gowns and packs

Electrical applications	Electric wire insulation & covering, friction tape and cable wrap, stuffing & identification.
Reinforced plastics	High and low-pressure laminates used in the manufacture of construction materials, process equipment, transportation uses and marine, missiles, molded electrical parts, housing, seating, trays, etc.
Felts	Wet & dry papermakers' felts, mattress felts, cushioning and wicking felts.
Filtration	Woven & nonwoven filters for wet & dry filtration, tea bags.
Sewing thread	Home sewing, industrial and weight goods, medical sutures
Bags & bagging	Synthetic yarn in nylon mailbags, olefin lomo mesh & closewoven bags, sandbag, olefin bags for wool bales, carpet backing bale wrap.
Coated & protective fabrics	Tents & tarpaulins, substrates for vinyl, rubber or urethane coating, lamination or impregnation, parachutes, deceleration chutes & tow targets, awnings, beach, garden & tractor umbrellas, inflatable dunnage & cushions, airbags and boat & pool covers
Paper & tape reinforcing	Gummed and pressure sensitive tapes, nonwoven bonded structure for paper, tape and ribbon reinforcing
Fiberfill, stuffing & flock	Used in all applications (apparel, home textiles & industrial)
Miscellaneous	Abrasives, book binding, luggage & handbags, shoes & slippers, tobacco cloth, woven wiping cloths and wall-covering fabrics

Source: Fiber Organon (October 2001)⁴ and Manufacturing Fiber Handbook¹⁶

Table 2.5 details 23 end use applications for technical and industrial textiles, as identified by *the Modern Textile Dictionary* (p.479-482, 1963)¹⁰, together with details of next tier products in which textiles are used.

[Table 2.5] Uses of cotton in Industrial fabrics

End use applications	Next Tier Products
Airplane etc	Fuselage, gas, cells, wings.
Athletic equipment	Covers, mats, nets, pads
Automobiles, etc	Body, seats, tires, top
Bags	Feed, flour, salt, sugar
Barber supplies	Hair aprons, pads, towels
Belting, etc	Belts, conveyors, hose
Building supplies	Awnings, insulation, shades, wall covering
Canvas shelters	Canopies, tarpaulins, tents
Farm equipment	Aprons, benders, covers
Filter cloths	Chemicals, foods, oil, sugar
Flags and display	Bunting, signs, stage property
Furniture	Chairs, cots, upholstery
Insulation	Cords, tapes, wires
Laundry supplies	Covers, net, padding, twine
Luggage	Bags, cases, trunks
Marine equipment	Covers, lines, nets, sails
Meat packaging	Casings, covers, twines
Medical supplies	Absorbent cotton, gauze, tape
Mortuary supplies	Caskets, shrouds, straps
Office equipment	Machine covers, pads, ribbons
Publishers' supplies	Bindings, book covers
Railroad equipment	Car fitting and supplies
Shoe materials	Canvas shoes, linings, rubbers

Source: The Modern Textile Dictionary¹⁰

2.4 End-use Markets for Technical and Industrial Textiles

According to Kotler⁶ (*Marketing Management*, p216), the major industries making-up the business market are agriculture, forestry and fisheries; mining; manufacturing; construction; transportation; communication; public utilities; banking, finance and insurance; distribution and services.

Fairchild's Dictionary of Textiles (p.285, 1996)¹³ notes that applications fall into several classes:

- (1) a broad group including fabrics employed in industrial processes, e.g., filtering, polishing, absorption,
- (2) fabrics combined with other materials to produce new types of product, including
 - rubberized fabric for hose, belting, tires;
 - fabric combined with synthetic resins into composites for timing gears, electric machinery parts;
 - coated or enameled fabrics for automobile tops, book bindings;
 - fabrics impregnated with adhesive and dielectric compounds for applications in the electrical industry;
- (3) fabrics incorporated directly in a finished product including sails, tarpaulins, tents, awnings, specialty belts for agricultural machinery, airplanes, and conveyors.

In *the Modern Textile Dictionary* (p.479-482, 1963)¹⁰, Linton identified intermediate and end-use destinations for woven technical fabrics. These are shown in Table 2.6.

[Table 2.6] End-use Destinations for Woven Technical Fabrics

1. The mechanical rubber trade
2. The rubber, oilcloth, and pyroxylin trade
3. The shoe trade
4. The use of filtering media
5. The laundry supply trade
6. The converting trade
7. The tent and awning trade
8. Specialty manufacturers
9. The dry goods, jobbing and chain-store trade
10. Flag manufacturers
11. The clothing and work-clothing trade
12. Miscellaneous industries, including
 - Adhesive industry
 - Airplane and balloon: balloon fabric, wing fabric
 - Army and navy:
 - Automobile industry
 - Bakelite and synthetic resin
 - Buffing wheel manufacturers
 - Railroads
 - Shipping covers
 - Spring covers
 - Upholstery padding

Source: The Modern Textile Dictionary¹⁰

The National Cotton Council of America identifies 23 end-uses for technical and industrial textiles, as Table 2.7 details.

[Table 2.7] Technical Textile Fabric End-uses

Abrasives, principally woven	Rope, cordage & twine, excl. hard fiber/jute/paper
Automobile uses	Shoes & boots, excl. waterproof
Awnings, woven	Sleeping bags, woven
Bags, woven	Tape pressure sensitive, excl. medical
Belts, Machinery (textile content only)	Tarpaulins, woven
Boat covers & tops, woven	Tents & camper trailers, woven
Book bindings, excl. looseleaf binders	Tread, industrial
Filter cloth, woven	Tobacco cloth
Hose (textile content only)	Wall covering fabric (coated), woven & nonwoven
Luggage, handbags & purses	Wiping & polishing cloths, woven
Medical supplies	Zipper tape, narrow woven
Papermaker's felts, woven	

Source: Cotton Counts its Consumer¹⁷

Textile Terms and Definitions (p.340, 1995)¹² also provides a sample of end-uses for technical textiles, including: aerospace, industrial, marine, medical, military, safety and transport textiles, and geotextiles.

Hermann (cited in Reckfort) follows the textile finishing industry association by focusing on areas of application. These include: shaped products; body protection; filtration materials; geotextiles; transport textiles; netting; industrial textiles; packing materials; medical textiles; and industrial temperature protection.¹⁸

Perhaps the most widely-known classification of technical and industrial textile markets is that of Messe Frankfurt's Techtexsil. They define 12 main end-use markets for technical textiles. These are listed in Table 2.8. These terms and definitions are not universally used and they are not without their problems. Their main shortcoming is that they are market based definitions and therefore ignore other important criteria that can be used to define industrial sectors or sub-sectors, such as fiber (cotton industry, jute

industry); process technology (composites industry, nonwovens industry); activity (fiber industry, finishing industry); or product (carpet industry). Notable, also, is the absence of the military market, the products of which are subsumed under other categories. However, the Tectextil typology provides the most comprehensive attempt to classify the structure of end-use markets for technical textiles.

The Tectextil definitions depart from the traditional definitions in that they attempt to identify end-use markets for technical textiles. Markets classified by economic activity (agriculture) or application (packaging). Within these definitions may be product of diverse manufacturing activities e.g. tire cords, trunk liners and upholstery fabrics. Products may also have diverse end-uses within these markets - for example fishing nets or tarpaulins in agricultural end uses.

Some of these definitions are by broad economic activity e.g. Agrotech and some of them are defined by product function e.g. Protech. However, there is overlap between classifications and, from the manufacturing viewpoint, a lack of coherence to these. For example, some agricultural textiles, some construction textiles, and some geotextiles provide protective functions. (See Table 2.8 and appendix B)

[Table 2.8] End-use Based Divisions of the Technical Textile Industry According to Techtexsil

Designation	End-Uses	Applications
Agrotech	Agriculture, Horticulture Forestry and Fishing	Cover, Protection, Collection, Fishing, Tying
Buildtech	Building and Construction	Protection, Display, Textile Constructions, Building Components, Reinforcements
Clothtech	Technical Components of Shoes and Clothing	Shoe Components, Insulation, Structure, Sewing Products
Geotech	Geotextiles, Civil Engineering	Stabilisation, Separation, Drainage, Soil Reinforcement, Erosion Control, Linings
Hometech	Components of Furniture, Household Textiles and Floor Coverings	Carpet Components, Furniture Components, Cleaning, Filtration, Tickings, Composites
Indutech	Filtration, Cleaning and Other Industrial Materials	Filtration, MRGs, Cleaning Lifting, Pulling, Electrical Components, Other
Medtech	Hygiene and Medical	Cleaning, Coverstock, Woundcare, Protection
Mobiltech	Automotive, Marine, Railways and Aerospace	MRGs, Safety, Trim, Insulation, Floorcovering, Protection, Composites, Other
Packtech	Packaging	Bulk Packaging, Disposable, Tying, Other
Protech	Personal and Property Protection	Particulate Protection, Chemical Protection, Flame Retardant, Cut Resistant, Outdoor Use, Other
Sporttech	Sport and Leisure Equipment	Luggage Components, Sports Equipment, Camping Equipment, Other
Oekotech	Environmental protection	Products extracted from the above

Source: Techtexsil/ David Rigby Associates¹⁹

Finally, as shown in Table 2.9, it is important to review government definitions of technical and industrial textiles through the Standard Industrial Classification (SIC) and newer North American Industrial Classification (NAICS) schemes.

[Table 2.9] Technical and Industrial Textiles in North American Industrial Classification

NAICS	Manufacturing Sector	Productions
31323	Nonwoven fabric mills	<ul style="list-style-type: none"> • Nonwoven fabrics • Fabricated nonwoven products • Pressed, punched, or needled felts (except hats)
314911	Textile bag mills	<ul style="list-style-type: none"> • Duffle bags and knapsacks, all materials (including cotton canvas and open~mesh cotton) • All other textile bags • Textile bags, nsk
314912	Canvas & related product mills	<ul style="list-style-type: none"> • Canvas and related products made from cotton, nylon, polyester, and other industrial fabrics, awnings • Camping tents made from cotton, nylon, polyester, and other industrial fabrics • Other tents, including air supported structures and tension structures, made from cotton, nylon, polyester, and other industrial fabrics • Tarpaulins and other covers, flat, made from cotton, nylon, polyester, and other industrial fabrics • Tarpaulins and other covers, fitted, made from cotton, nylon, polyester, and other industrial fabrics • All other canvas products, including canvas sails, except bags • Canvas and related products, nsk
314991	Rope, cordage & twine mills	<ul style="list-style-type: none"> • Cordage and twine, hard fiber • Cordage and twine, soft fiber (except cotton) • Cotton cordage and twine
314992	Tire cord & tire fabric mills	<ul style="list-style-type: none"> • Tire cord and tire fabrics • Tire cord and tire fabrics, nsk
314999	All other miscellaneous textile product mills	<ul style="list-style-type: none"> • Recovered fibers, processed mill waste, and related products • Paddings and upholstery filling, batting, and wadding (excluding foam rubber and plastics) • Embroideries (except Schiffli machine products) • Other trimmings and findings • Fabricated textile products, nec
<ul style="list-style-type: none"> • See appendix C for bridge between SIC and NAICS 		

Source: 1997 Economic Census, US Census Bureau²⁰

2.5 Bases for Classifying Technical and Industrial Textiles

Svedova (*Industrial Textiles - Textile science and technology*, v. 9, 1990)¹¹ notes that technical textiles can be classified from several viewpoints:

- On the basis of the raw material processes
- On the basis of the manufacturing sector
- On the basis of the final application
- On the basis of the production technique and finish applied
- On the basis of the main industrial textiles groups and the specification of current and future application.
- Other bases

Wellington Sears handbook of industrial textiles (1995)¹³ similarly states that industrial textiles can be classified either according to:

- the raw material processes (e.g. industrial textiles made of glass fibers)
- the manufacturing sector and/or production techniques (e.g. nonwoven industrial textiles)
- the basis of main industrial textile group (e.g. canvas, filter cloth)
- the end use (e.g. geotextiles, medical textiles, paper machine cloth)

or on the basis of the final application:

1. Textiles in agriculture
2. Textiles in architecture and construction
3. Textile structure composite
4. Filtration textiles
5. Geotextiles
6. Medical textiles
7. Military and defense textiles
8. Safety and protective textiles
9. Textiles in sports and recreation

10. Textile in transportation

11. General industrial textiles

3. US Output and Trade in Technical and Industrial Textiles

3.1 Introduction

Official data covering the technical textile industry is incomplete. Government data under the Standard Industrial Classification scheme (SIC) and the recently introduced North American Industry Classification System (NAICS) provide only a partial view of the technical textile industry. The definitions within both the SIC and NAICS systems (see Table 2.9 and appendix C) focus on broad activities or product categories such as yarn and thread mills, knitting mills and narrow fabric mills. Within this framework, there is a lack of definition with regard to end-use markets served. Many of the industry sectors defined under the above systems combine both companies involved in consumer textiles and those in technical products (including many who are involved in both). Hence, providing a clear picture of technical and industrial textile production trends via Census data is not possible. The analysis below therefore is confined to those technical and industrial textile sectors that are reasonably defined under NAICS classifications. These include nonwoven fabric mills, textile bag mills, canvas & related product mills, tire cord and tire fabric mills, rope, cordage & twine mills and all other miscellaneous textile product mills.

3.2 US Census Bureau Data on Technical and Industrial Textiles

3.2.1 Production of Technical and Industrial Products

In 2000, the total value of shipments of the technical and industrial textile sectors defined in NAICS [Table 3.1] reached about US\$16,100 million, with a 2% annual average growth rate from 1997. Strong value growth areas include canvas and related product mills (5%), tire cord and tire fabric mills (3 %) and nonwoven fabric mills (3%). A segment showing low value growth is textile bag mills (-3%).

Data for the cost of materials across the same sectors shows a strong growth rate in canvas and related product mills (5%) and tire cord and tire fabric mills (4%). By contrast, it shows a decrease in textile bag mills (-4%) and nonwoven fabric mills (-1%).

The Table also shows employment changes. The total workforce in these segments of the industry decreased slightly (-0.38%) between 1997 and 2000, reaching 129,100 in the latter year. The largest segment is all other miscellaneous textile product mills, with 40% of the total. This is followed by nonwoven fabric mills (17%), and canvas and related product mills (15%). The strongest employment growth rate has been in nonwoven fabric mills (2%), and canvas and related product mills (2%). Those showing rapid decline include textile bag mills (-9%) and all other miscellaneous textile product mills (-0.31%). The growth rate is relatively low mainly to due to increases in labor-saving capital investments and rapid import penetration.

[Table 3.1] Industry activities of technical textiles

		1997	1998	1999	2000	%GR
Value of shipments (\$ millions)						
31323	Nonwoven fabric mills	4,368	4,416	4,674	4,740	3%
314911	Textile bag mills	973	958	934	877	-3%
314912	Canvas & related product mills	1,529	1,558	1,672	1,759	5%
314991	Rope, cordage & twine mills	777	766	804	825	2%
314992	Tire cord & tire fabric mills	1,269	1,300	1,428	1,406	3%
314999	All other miscellaneous textile product mills *	6,208	5,897	6,732	6,493	2%
	Total	15,124	14,895	16,244	16,100	2%
Cost of Materials (\$ millions)						
31323	Nonwoven fabric mills	2,646	2,476	2,360	2,595	-1%
314911	Textile bag mills	486	466	451	434	-4%
314912	Canvas & related product mills	723	738	794	844	5%
314991	Rope, cordage & twine mills	411	404	421	446	3%
314992	Tire cord & tire fabric mills	858	925	1,003	979	4%
314999	All other miscellaneous textile product mills*	3,296	3,181	3,487	3,316	0%
	Total	8,420	8,190	8,516	8,612	1%
Total employment (thousands)						
31323	Nonwoven fabric mills	21.2	20.8	21.2	22.5	2%
314911	Textile bag mills	14.1	13.9	11.7	10.6	-9%
314912	Canvas & related product mills	18.7	18.7	19	19.7	2%
314991	Rope, cordage & twine mills	6.4	6.3	6.6	6.5	1%
314992	Tire cord & tire fabric mills	5.2	5	5.5	5.4	1%
314999	All other miscellaneous textile product mills*	65	60.5	68.9	64.4	0%
	Total	130.6	125.2	132.9	129.1	0%

* All other miscellaneous textile product mills include:

- Recovered fibers, processed mill waste, and related products
- Paddings and upholstery filling, batting, and wadding (excluding foam rubber and plastics)
- Embroideries (except Schiffl machine products)
- Other trimmings and findings
- Fabricated textile products, nec

** Detailed descriptions are provided in Appendix C.

Source: Annual Survey of Manufactures, US Census Bureau²¹

3.2.2 Consumption of technical and industrial textiles in US industry

According to the census data (see Table 3.2), textile products and semi-products used as raw materials in other industries reached 9,542 million dollars. Among the industries, transportation equipment manufacturing consumed approximately 26% of total textile products followed by furniture and related product manufacturing (25%), plastic and rubber products manufacturing (19%) and miscellaneous manufacturing (10%).

[Table 3.2] Textile material consumption in other manufacturing (\$1,000)

NAICS Code	Descriptions	1997	Share %
MINING			
212	Mining (except oil & gas)	16,057	0.17%
MANUFACTURING			
311	Food MFG	61,072	0.64%
316	Leather & allied product mfg	314,415	3.30%
321	Wood product mfg	207,509	2.17%
322	Paper mfg	854,448	8.95%
323	Printing & related support activities	164,513	1.72%
326	Plastic & rubber products mfg	1,841,190	19.30%
327	Nonmetallic mineral products mfg	169,485	1.78%
331	Primary metal mfg	0	0.00%
335	Electric equipment, appliance & component mfg	15,649	0.16%
336	Transportation equipment mfg	2,503,468	26.24
337	Furniture & related product mfg	2,412,463	25.28
339	Miscellaneous mfg*	981,769	10.29
Total		9,542,038	100

* Miscellaneous manufacturing includes Surgical & medical instrument manufacturing; Sporting & athletic goods manufacturing; Doll & stuffed toy manufacturing; Lead pencil & art goods manufacturing; Carbon paper & linked ribbon manufacturing; Sign manufacturing; Fastener, button, needle & pin mfg; and Broom, brush & mop manufacturing.

** See appendix D for more detail.

Source: 1997 Economic Census, Material Summary, US Census Bureau²²

3.3 Fiber Organon’s Measures of Technical and Industrial Fiber Consumption

3.3.1 Overall Shifts in US Fiber Consumption Since 1950

Between 1950 and 2000, total US mill fiber consumption increased from 6,214 million pounds to about 17,148 million pounds (see Table 3.3). At the same time, fiber consumption in industrial applications grew from 2,081 to 4,257 million pounds. Table 3.1 also shows that in two decades, 1950-1960 and 1980-1990, fiber consumption in industrial textiles actually contracted. However, the contraction in the 1980s partly reflects the exclusion of glass fiber from the data after 1985.

In terms of end-use share of fiber consumption (see Table 3.4), the share of apparel accounted for 35% of total fiber consumption followed by floor coverings (24%), industrial uses (25%) and home textiles (16%). As shown in Table 3.2, the share of apparel fluctuated around 40% up to 1990 but has since declined to around 35% in 2000. The share of industrial textiles fell from around one-third in 1950 to 22% in 1990. However, it has since increased to 25% in 2000. The most significant change has been in the share of floor coverings which have grown from just 7% of fiber consumption in 1950 to 25% in 2000.

[Table 3.3] US fiber consumption, average annual growth rate by end-uses

	1950	1960	1970	1980	1990	2000
Apparel	2,453	2,769	3,856	4,823	5,204	6,057
Home Furnishings	1,276	1,262	1,777	1,731	2,235	2,728
Floor Coverings	405	414	1,252	1,926	3,075	4,107
Industrial	2,081	1,952	2,653	3,120	2,965	4,257
Total	6,214	6,397	9,538	11,600	13,479	17,148
Average annual growth rate (%)	50-60	60-70	70-80	80-90	90-00	
Apparel	1%	3%	2%	1%	2%	
Home Furnishings	0%	3%	0%	3%	2%	
Floor Coverings	0%	12%	4%	5%	3%	
Industrial*	-1%	3%	2%	-1%	4%	
Total	0%	4%	2%	2%	2%	

* Excludes glass fiber consumption after 1985

Source: Textile Organon²³ and Fiber Organon⁴

[Table 3.4] The Share of US fiber consumption by end-uses

	1950	1960	1970	1980	1990	2000
Apparel	39%	43%	40%	42%	39%	35%
Home Furnishings	21%	20%	19%	15%	17%	16%
Floor Coverings	7%	6%	13%	17%	23%	24%
Industrial*	33%	31%	28%	27%	22%	25%

* Excludes glass fiber consumption after 1985

Source: Textile Organon²² and Fiber Organon⁴

3.3.2 Fiber Consumption in Technical and Industrial Textiles

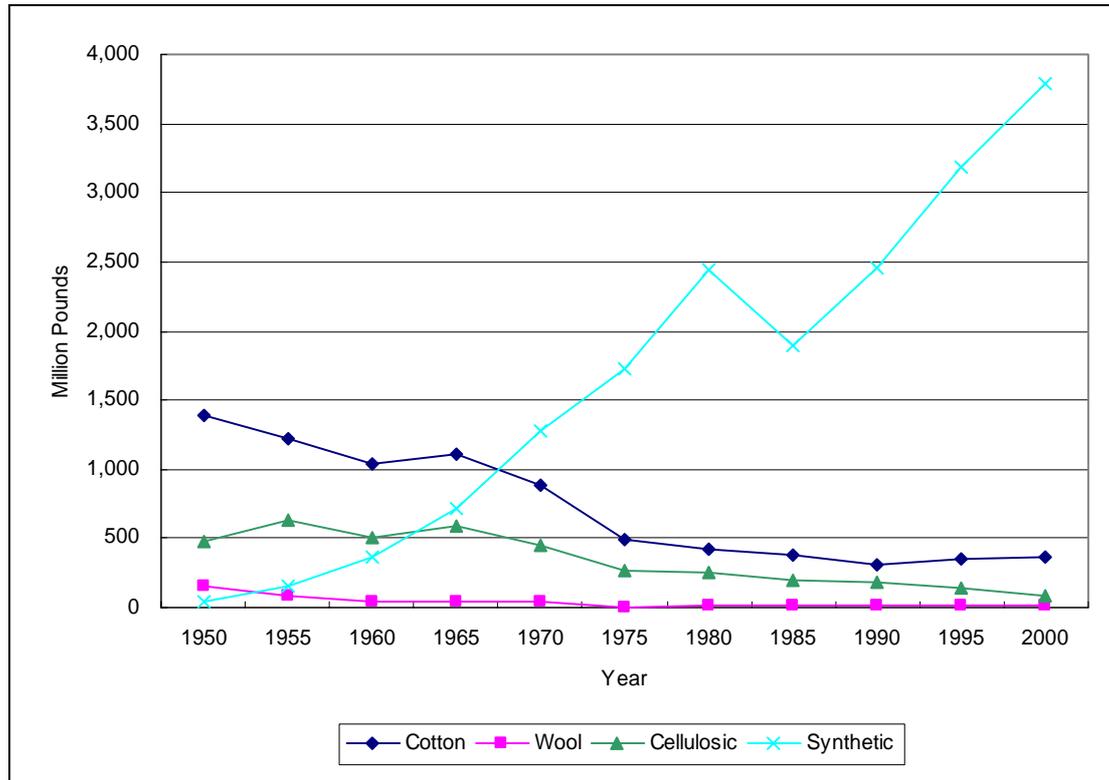
According to the Fiber Organon, US fiber (cotton, wool & manufactured fibers) consumption for industrial products reached 4,257 million pounds, which accounted for about 25% of fiber consumed in production of apparel, home textiles, floor coverings and industrial products. Among the top four fiber types (cotton, wool, cellulosic and synthetic), the latter accounted for 89% of total consumption in industrial end-uses followed by cotton (9%), cellulosic fibers (2%) and wool (see Figure 3.1 and Table 3.5).

Cotton was widely used for industrial applications until the latter half of the 20th century. However, it has subsequently become a minor fiber for industrial or technical textiles. In 1950, cotton consumption for industrial uses was 1,393 million pounds, which accounted for 34% of total cotton consumption and 67% of total industrial fiber consumption. By 2000, cotton consumption in industrial uses had decreased to 370 million pounds, which accounted for 7% of total cotton consumption and 9% of total industrial fiber consumption (see Figure 3.1 and Table 3.5).

Cellulosic fibers played an important role as a reinforcement material for tires, drive belts, conveyors and hoses until nylon and polyester fibers emerged. However, cellulosic fibers are still widely used in disposable nonwovens due to their good absorbency.

Consumption of synthetic fibers has grown from 48 million pounds or just 2% of the total in 1950, to 3,785 million pounds or 89% of total technical and industrial fiber consumption (see Figure 3.1 and Table 3.5).

[Figure 3.1] Fiber consumption in industrial end-uses by fiber type



Source: Textile Organon²² and Fiber Organon⁴

[Table 3.5] Annual growth rate and share of fiber consumption in industrial end-uses by fiber type

Annual Average Growth Rate (%)											
	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-00	
Cotton	-3%	-3%	1%	-4%	-11%	-3%	-2%	-4%	3%	1%	
Wool	-10%	-17%	3%	0%	-32%	13%	3%	-5%	8%	-3%	
Cellulosic	5%	-4%	3%	-5%	-10%	-1%	-5%	-1%	-5%	-9%	
Synthetic	27%	18%	14%	12%	6%	7%	-5%	5%	5%	4%	
Total*	0%	-1%	5%	1%	-1%	5%	-5%	4%	4%	3%	
Share (%)											
	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Cotton	67	58	53	45	33	20	14	15	11	10	9
Wool	7	4	2	2	2	0	0	1	0	0	0
Cellulosic	23	30	26	24	17	11	8	8	6	4	2
Synthetic	2	8	19	29	48	69	78	76	83	86	89

* Excludes glass fiber consumption after 1985

Source: Textile Organon²² and Fiber Organon⁴

3.3.3 Trends in synthetic fiber consumption

In 2000, US consumption of major synthetic fibers, such as nylon, polyester, acrylic and olefin totaled 2,889 million pounds. The average annual growth rate between 1996 and 2000 was 3%. Among the fiber types, polyester accounted for 52% of the total followed by olefin (38%) and nylon fiber (9%). However, olefin fiber showed the strongest growth rate (8%) compared with polyester (1%) and nylon (-6%). This was mainly due to its advantage in cost and ease of processing that increased its usage, especially in the nonwovens industry (see Table 3.6).

[Table 3.6] US synthetic fiber shipment for industrial uses by selected fiber types (million pounds)

	1996	1997	1998	1999	2000	Growth%	Share %
Total	2,609	2,696	2,734	2,905	2,889	3%	100%
Nylon Yarn+Monofilament	319	339	315	309	246	-6%	9%
Polyester Total	1,438	1,480	1,458	1,511	1,515	1%	52%
Polyester Feed & Producer textured Yarn	141	174	181	189	213	11%	
Polyester Flat Yarn	430	453	448	458	431	0%	
Polyester Staple+Tow	867	854	828	863	871	0%	
Acrylic Staple+Tow	40	40	43	43	34	-4%	1%
Olefin Total	813	837	919	1,041	1,094	8%	38%
Olefin Yarn, Film, Monofilament & Spunbobbed	496	508	555	569	598	5%	
Olefin Staple+Tow	316	329	364	472	496	12%	

Source: Manufactured Fiber Handbook¹⁶

3.3.4 Fiber distribution in technical textile products

Table 3.7 indicates the relative size and growth rate of US fiber consumption in technical textile products between 1991 and 2000. Miscellaneous items (see definitions in Table 2.3) accounted for the largest volume of fibers consumed, followed by fiberfill, medical textiles, nonwoven fabrics not incorporated elsewhere, and tires. Of these, unallocated nonwoven items show the strongest average annual growth rate (9%). Other strong volume growth areas include miscellaneous items (6%), transportation fabrics (6%),

tires (4%), and fiberfill, stuffing and flock (4%). Segments showing low volume growth include medical textiles (2.3%), tires (2.2%) and felts (3.9%). Other areas show contracting fiber usage between 1991 and 2000. These include bags (-4%), electrical and reinforced plastics (-3%), and Paper and tape reinforcing (-2%).

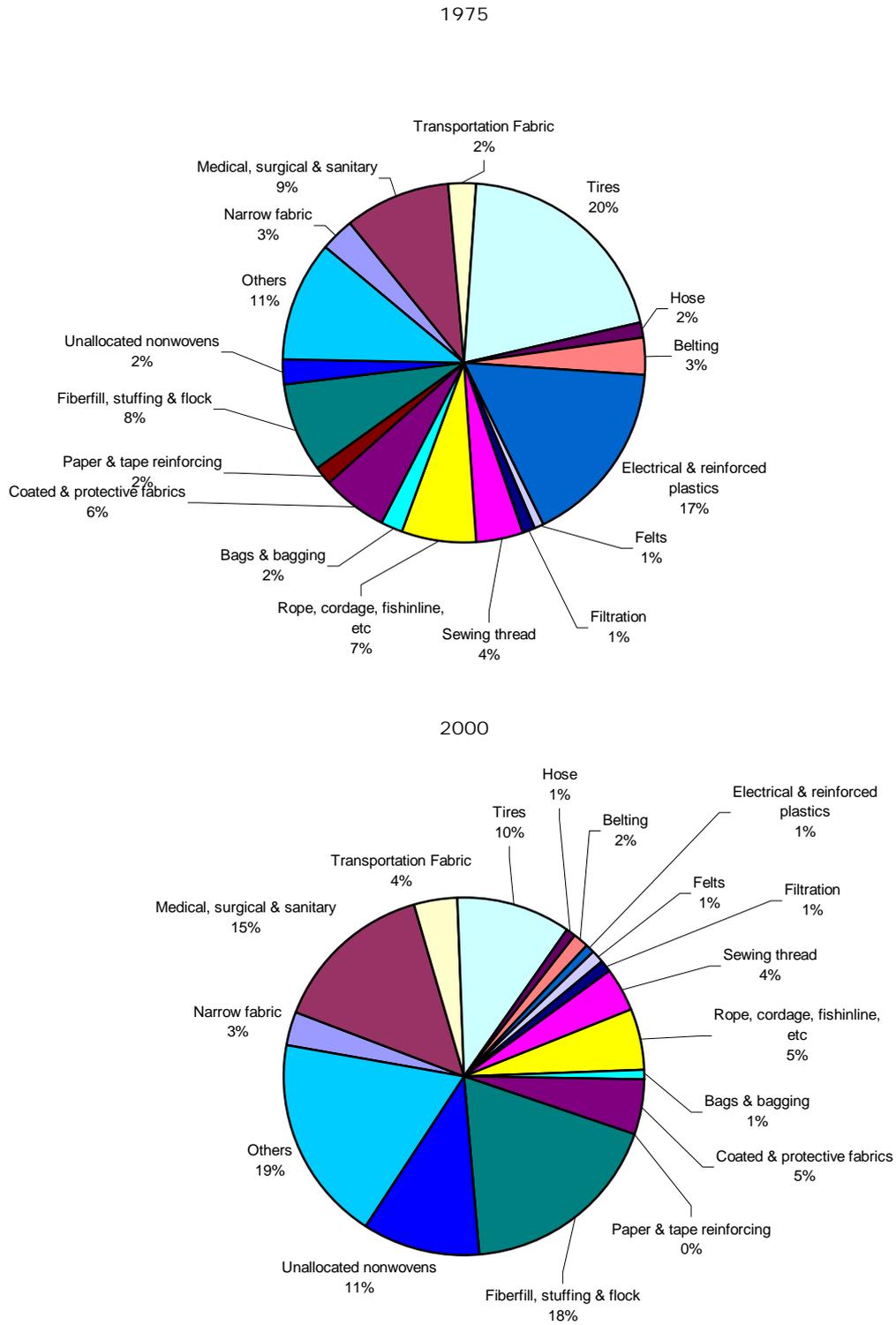
[Table 3.7] Total Fiber Consumed in US Technical-Type Textile Products (Million pounds)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	%GR
Narrow fabric	137	140	140	154	150	144	144	139	137	128	-1%
Medical, surgical & sanitary	599	558	566	606	591	572	585	600	604	627	1%
Transportation Fabric	100	104	126	154	149	124	144	158	161	168	6%
Tires	307	352	377	401	409	405	417	398	412	442	4%
Hose	32	34	37	36	42	41	46	32	31	28	-1%
Belting	55	56	57	57	56	52	64	71	70	65	2%
Electrical & reinforced plastics	41	40	43	35	35	32	30	29	30	31	-3%
Felts	45	50	47	53	47	40	39	45	47	47	0%
Filtration	41	35	35	35	35	35	39	42	46	48	2%
Sewing thread	142	153	179	189	187	176	177	175	176	171	2%
Rope, cordage, fishing line, etc	204	219	197	215	240	234	228	243	243	233	1%
Bags & bagging	59	47	54	58	59	60	60	46	46	42	-4%
Coated & protective fabrics	235	252	273	257	239	228	222	215	215	206	-1%
Paper & tape reinforcing	7	6	7	7	9	7	7	7	7	6	-2%
Fiberfill, stuffing & flock	555	562	660	605	603	604	699	785	833	771	4%
Unallocated nonwovens	209	233	235	239	274	342	342	366	397	449	9%
Miscellaneous	475	470	469	473	556	613	630	669	775	798	6%
Total	3,243	3,311	3,502	3,574	3,681	3,709	3,873	4,020	4,230	4,260	3%

Source: Fiber Organon⁴

Figure 3.2 shows the relative share of these products in US mill fiber consumption in 1975 and 2000. Overall, it does not show significant change in the use of technical and industrial textiles. Transportation items (transportation fabrics and tire) have been the largest areas in technical and industrial textiles and there was considerable increase in the use of nonwovens (unallocated nonwovens) from 2% to 11%. The sharp decline in electrical reinforced plastics is mainly due to the exclusion of glass fiber consumption after 1985. Other items do not show considerable changes in their use.

[Figure 3.2] Share of Fiber Consumption by End-use for Technical textiles in the US



Source: Textile Organon²² and Fiber Organon⁴

3.4 National Cotton Council estimates of technical and industrial textile output

Table 3.8 provides details of production of various technical textile products in the US between 1996 and 2000, based on National Cotton Council data¹⁷. The strong volume growth products include belts (10%), rope, cordage & twine (4%) and medical supplies (3%). Products showing high rates of decline include shoes & boots (-18%), bags (-8%), tobacco cloth (-7%) and tarpaulins (-6%).

[Table 3.8] Unit Production of Technical End-use Items

	1996	1997	1998	1999	2000	GR %
Abrasives, principally woven (Mil. Syds)	83	85	86	91	90	2%
Automobile uses* (Mil. Syds)	367	350	353	381	348	-1%
Tire cord & tire cord fabric (Mil. Lbs)	972	1,002	1,052	942	1,077	3%
Awnings, woven (Mil. Syds)	42	44	46	76	45	2%
Bags, woven (Mil. Lyds)	321	320	329	280	227	-8%
Belts, Machinery (textile content only) (Mil. Lbs)	41	54	56	58	60	10%
Boat covers & tops, woven (Mil. Syds)	62	33	64	65	66	2%
Book bindings, excl. loose-leaf binders (Mil. Syds)	263	264	264	256	259	0%
Filter cloth, woven (Mil. Syds)	47	49	51	53	52	3%
Hose (textile content only) (Mil. Lbs)	37	37	38	38	39	1%
Luggage, handbags & purses (Mil. Syds)	146	149	151	154	158	2%
Medical supplies (Mil. Syds)	3,397	3,607	3,787	3,914	3,887	3%
Papermaker's felts, woven (Mil. Syds)	11	11	11	11	11	0%
Rope, cordage & twine (Mil. Lbs)	182	184	182	202	212	4%
Shoes & boots, excl. waterproof (Mil. Syds)	75	67	38	38	34	-18%
Sleeping bags, woven (Mil. Syds)	97	96	97	98	100	1%
Tape pressure sensitive, excl. medical (Mil. Syds)	662	665	685	710	740	3%
Tarpaulins, woven (Mil. Syds)	99	100	102	86	77	-6%
Tents & camper trailers, woven (Mil. Syds)	137	143	142	139	125	-2%
Thread, industrial (Mil. Lbs)	181	182	187	194	202	3%
Tobacco cloth (Mil. Syds)	75	82	70	65	55	-7%
Wall covering fabric (coated), woven & nonwoven (Mil. Syds)	202	212	210	206	201	0%
Wiping & polishing cloths, woven (Mil. Syds)	44	43	44	47	44	0%
Zipper tape, narrow woven (Mil. Syds)	17	17	17	17	16	-2%

Notes: Syds -- Square Yards, Lbs. -- Pounds, Lyds. -- Linear Yards

* Automobile uses, Belts and Hoses are estimated volume and not exactly matched with original source data

Source: Cotton counts its customers¹⁷

Table 3.9 shows the relative size and growth rate of woven and knitted fabric consumption in technical textile products between 1985 and 2000. 'Other items', comprising tire cord, tufting yarns, thread, rope, cordage and twine accounted for about 1,580 billion pounds, which is the largest volume consumption for technical textiles, followed by woven fabrics (993,830 million pounds) and knitted fabric (20,856 million pounds). Although they had experienced strong growth rates between 1985 and 1995, in recent times overall volumes show a low growth rate, with knit fabrics experiencing a steady decline.

[Table 3.9] Woven and Knitted Fabric Consumption for US Industrial Textiles (Thousand Square Yards and Million Pounds)

	1985	1990	1995	2000	GR 85-90	GR 90-95	GR 95-00
Consumption in thousand-square yards							
Knit *	60,978	61,129	76,471	66,502	0%	5%	-3%
Woven *	5,256,731	5,843,693	6,123,579	6,481,920	2%	1%	1%
Consumption in million pounds							
Knit	17,468	17,740	24,662	20,856	0%	7%	-3%
Woven	872,116	910,526	1,030,383	993,830	1%	3%	-1%
Other **	893,033	1,167,433	1,383,381	1,575,058	6%	3%	3%

* Square yards of woven and knitted fabric consumption includes competing materials such as Plastic film, leather and paper

** Other includes tire cord, tufting yarns, thread, rope, cordage, twine, etc.

Source: Cotton counts its customers¹⁷

3.5 Trade in technical and industrial textiles

In 2001, the value of exports reached 1,597 million dollars with almost 0% average annual growth rate while value of imports was 2,863 million dollars with a strong average annual growth rate of 9% (see Table 3.10). As a result, the trade deficit was 1,266 million dollars in 2001, a 29% increase from 463 million dollars in 1997.

The largest segment of exports (in terms of value) is accounted for by nonwoven fabric mills (47%) followed by all other miscellaneous textile product mills (35%), and tire cord and tire fabric mills (8%). Rope, cordage and twine mills show the strongest growth, averaging 6% per annum, while other sectors show a low growth rate or even a decline.

All other miscellaneous textile products accounted for 54% of total imports (in value terms) followed by nonwoven fabric mills (9%). Those showing the strongest growth rate include textile bag mills (17%), all other miscellaneous textile product mills (11%), and nonwoven fabric mills (9%).

[Table 3.10] Exports and imports of technical textiles (\$ Millions)

Value of Exports							
		1997	1998	1999	2000	2001	%GR
31323	Nonwoven fabric mills	769	733	674	761	757	0%
314911	Textile bag mills	32	35	28	27	31	-1%
314912	Canvas & related product mills	45	46	51	46	40	-3%
314991	Rope, cordage & twine mills	64	75	69	78	81	6%
314992	Tire cord & tire fabric mills	159	154	162	158	133	-4%
314999	All other miscellaneous textile product mills	528	533	611	682	555	1%
	TOTAL	1,597	1,576	1,595	1,752	1,597	0%
Value of Imports							
31323	Nonwoven fabric mills	265	277	286	355	372	9%
314911	Textile bag mills	114	139	161	203	210	17%
314912	Canvas & related product mills	228	248	249	234	252	3%
314991	Rope, cordage & twine mills	223	229	220	249	259	4%
314992	Tire cord & tire fabric mills	202	210	208	214	210	1%
314999	All other miscellaneous textile product mills	1,028	1,160	1,327	1,429	1,560	11%
	TOTAL	2,060	2,263	2,451	2,684	2,863	9%
Trade Balance							
		-463	-687	-856	-932	-1,266	29%

Source: International Trade Administration²⁴

4. Industry Demographics and Development Trends

4.1 Industry Structure

Overall, the structure and composition of the technical textile industry is as diverse as the products it manufactures and the markets that it serves. In some respects it is a microcosm of the textile –fiber complex as a whole, comprising large multi-national corporations, such as Du Pont and Freudenberg, through large domestic and international companies, such as Milliken, together with a multitude of small and medium-sized companies. The latter are typically highly specialized, focusing on a specific process or product. As a crude rule of thumb, larger companies tend to be found upstream in the fiber, yarn and fabric forming sectors. Smaller and medium-sized companies are more prominent in the downstream finishing and fabricating sectors of the industry.

Although some larger companies, such as Milliken, have diversified technical textile activities and markets, it is believed that there are few companies that could be classified as diversified technical textile groups. For example, although a company like Freudenberg does supply a diverse range of markets, their focus is on nonwoven products.

Market entries into the technical textile arena are typically achieved by one of three mechanisms:

- New business start-ups, involving entrepreneurs who perceive new market opportunities or who have developed new product technologies and obtained financial backing;
- Diversification of established textile companies into technical markets through internal development or acquisition, as markets in consumer products are lost;
- The entry of foreign technical textile companies into the US market through acquisitions or green-field investments.

There is no documentary evidence as to the relative importance of these three mechanisms. However, it is likely that all three are significant and that diversification of established companies is probably the most important of the three.

In parallel with the mainstream textile industry, the production chain from fiber to finished product can be long and complex. Basic fabric substrates can be processed in a variety of means to achieve specific effects, such as waterproofing, or they may be combined into composites. These will then often be subject to further processing including fabrication and assembly into a finished product, either as the item itself or as a component of a larger product.

4.2 Industry Drivers and Development Trends by Sector*

Demand for technical textiles is closely linked to the overall level of economic activity in the economy. Hence, as evident in the trends described above it is a relatively low growth industry. However, demand is also being driven by technical innovation that is resulting in the wider application of textile materials across a broad range of end-uses, often through substitution for other materials.

Clearly, demand for specific products is tied closely to the fortunes of the diverse market segments they service. Below, the market drivers and development trends across the range of end-use markets broadly defined by Techtextil (but including a military segment) are briefly outlined.²⁵

4.2.1 Agricultural Textiles

This market comprises all textiles that are used by the agricultural and fishing industries, including such diverse items as nets, ropes, twine, and fabrics for cover and containment. The agricultural market is driven by the benefits technical textiles provide in terms of improved productivity and reduced need for chemicals. Overall, this sector represents a low growth area and products are below average unit value for the technical textile industry. (See appendix E)

* This part is based on “*The world technical textile industry and its markets: prospects to 2005*” (see reference no. 3) and “*US market for technical textiles*” (see reference no. 25)

4.2.2 Building and Construction Textiles

The building and construction market represents a moderate growth segment for technical textiles. Large quantities of relatively low value textiles are used in building for insulation purposes. The market is very cyclical in nature but has strong development potential. Building safety and health standards require development, testing and acceptance procedures and buying influences include architects, construction engineers, contractors and regulatory bodies. It is believed that an area with strong potential is temporary and semi-permanent structures for emergency shelter and commercial events. (See appendix E)

4.2.3 Packaging

This market comprises diverse packaging uses, including traditional bags and sacks made from jute, cotton and flax but increasingly from woven polypropylene. An important segment is so-called flexible intermediate bulk containers (FIBCs) for powdered and granular materials. Another non-traditional product application is the use of lightweight nonwovens and knitted structures for the food industry. These include knitted netting for fruit, absorbent mats for fresh produce, and nonwovens for tea and coffee bags. Another segment is textile reinforcement for tapes and envelopes. The packaging market is the most vulnerable area to foreign competitions, though there is a growing (environmental) need for re-usable packages and containers and it is believed there will be new opportunities for textile products in this market. (See appendix E)

4.2.4 Geotextiles

Geotextiles are used in rail and road embankments, reservoirs, river and coastal protection, and landscaping. Geotextile functions include reinforcement stabilization, separation, containment drainage and filtration. Some applications are temporary and some are permanent. The market is characterized by a great diversity of needs - no two installations are the same. Product values are usually low but installations can use vast quantities of fabric.

Nonwovens account for the bulk of demand, due to a combination of economics and technical characteristics. However, there is increasing interest in composite fabrics that combine the advantages of different textile constructions, including knitted fabrics, woven, nonwovens and membranes. Overall, this market is small but is expected to grow strongly as geotextiles become more widely applied. (See appendix E)

4.2.5 Protective textiles and safety clothing

These products comprise fabrics used in apparel and non-apparel applications for protection against cuts, abrasion, ballistic and other forms of impact, fire and heat, hazardous materials, electricity, weather, cold and poor visibility. They also include protection for instruments and processes – e.g. clean rooms. The market is quite small but exhibits moderately strong growth and products are generally of high unit values. Due to increasing health and safety issues at work this may be an increasingly attractive segment. (See appendix E)

4.2.6 Sports Textiles

Due to the increase of interest in sports and outdoor activities and the influence of major sports events such as World Cup and Olympic games, this sector is expected to show a high growth rate. Today's sports and outdoor activities demand high performance equipment and apparel. The light weight and safety features of textile products have become important in their substitution for other materials. (See appendix E)

4.2.7 Medical and hygiene textiles

The largest medical and hygiene markets are baby diapers, wipes, adult sanitary and incontinence products. These markets are relatively mature (except perhaps the last). Also, as many are disposable – they add a significant burden on the environment. Medical and surgical products include low value-added items such as bedding and gowns, and medium to very high value added products such as dressings, sterilization packs, sutures and orthopedic products. Hi-tech products such as sutures have a long product development, testing

and commercialization time. Also, many companies are deterred by the medical industry's reputation as a target for litigation. (Interviews with industry respondents)

High growth is confined to innovative highly specialist items. Overall, unit values are above average for the industry. (See appendix E)

4.2.8 Home textiles

One of the largest technical textile markets, this sector comprises household textiles and furnishings used in contract applications and by the upholstered furniture industry. The latter include fiberfill and wadding applications in bedding, cushions, sleeping bags and furniture backings.

The output of this sector shows slightly-below average unit values for the industry. Market growth has been reasonably strong. (See appendix E)

4.2.9 Clothing components

This sector comprises sewing threads, interlinings, waddings and insulation materials used in clothing and footwear. Given the contraction of the US apparel industry the market has declined. However, the expansion of apparel manufacturing in the Caribbean basin still offers growth prospects for US companies and products have high unit values, suggesting a specialized industry. (See appendix E)

4.2.10 Industrial textiles

This segment includes textiles used directly in industrial applications or incorporated into other industrial products, such as filters, conveyor belts and abrasive belts, as well as reinforcements for printed circuit boards and seals, gaskets and others industrial equipment. This is one of the largest market sectors and a moderately strong growth area. (See appendix E)

4.2.11 Transportation textiles

This sector comprises all textiles used in cars, trucks, trains and aircraft. It is the second largest market sector in North America. Products range from carpeting, trunk-liners, upholstery, through beltings, tire cords and composites for aircraft bodies. The market is mature and consequently shows only low growth. Unit values, however, are above average for the industry. (See appendix E)

4.2.12 Military textiles

This is a large end-use market comprising a mixture of low value/ low tech and high value/hi-tech products. It includes uniforms, medical products, composites used in military equipment, temporary buildings, camouflage fabric, netting and FIBCs. This is also an area of considerable technical development and potential growth.

4.3 Company strategies

Intensified competition in apparel and household textile markets is encouraging more textile companies to seek new avenues for business development, including expansion into technical textile markets.

They are being hindered by barriers to entry including, a lack of information about these markets; the high costs of new product development and/or alteration of production set-ups; and the difficulty of breaking into segments where strong relationships bind customers to established suppliers.

These problems are encouraging realignment through mergers, acquisitions and divestitures, as companies seek to build positions in and release resources by exiting weaker business areas.

Since technical markets are not immune to competition from developing countries, many US companies are focusing on high specification, high-tech products. Through investment in product innovation and high levels of service they are developing close partnerships with customers to open-up new growth markets and

provide insulation from international competition. An increasing number of companies are also discovering export opportunities for technical textiles. Across many developing countries there is a growing need for these products but an inadequate industrial base to manufacture them. Increasingly, US firms are finding attractive markets abroad.

5. Conclusion

5.1 General

Overall, as competition continues to escalate across traditional apparel-related textile sectors, many US textile companies are seeking to switch over to technical products that are less vulnerable to import and price changes. The growth rate of most technical textile segments is not high but contrasts sharply with the declining fortunes of the apparel-related segments of the industry.

According to David Rigby³, the consumption of world technical and industrial textiles in 2000 was \$60,271 million with annual growth averaging 3.8%. The North American market at \$16,982 million was second only to Asia in 2000 at \$20,564 million (see Table 5.1). This growth is expected to continue, providing new opportunities for US textile manufacturers.

[Table. 5.1] Technical textiles end use consumption by region (\$ million)

	1985	1990	1995	2000	2005	%CAGR 85-95	%CAGR 95-05
W. Europe	9,018	11,188	12,229	13,771	15,733	3.1	2.6
E. Europe	2,543	3,107	1,736	2,501	3,261	-3.7	6.5
N. America	11,281	13,381	15,264	16,982	18,923	3.1	2.2
S. America	1,060	1,195	1,550	1,865	2,271	3.9	3.9
Asia	7,543	11,430	15,880	20,564	25,866	7.7	5
Australasia	472	544	630	762	904	3.9	3.7
Rest of World	1,243	1,683	2,673	3,826	5,371	9	7.2
Total	33,160	42,528	49,962	60,271	72,329	4.2	3.8

Source: David Rigby Associate³

The most important part of US technical and industrial textiles has been transportation manufacturers, which spent \$2,503 million and consumed 610 million pounds of fibers. (See Table 3.2 and Table 3.7)

Fiber consumption in US technical and industrial textiles in 2000 was 4,257 million pounds, representing a 4% increase on the previous year. (See Table 3.3)

Recent trends in the production of technical and industrial textiles are the increase in uses of olefin fibers and nonwoven fabrics that can help companies reduce the cost of materials without reducing the quality of their products. (See Table 3.6)

Although they are considered as a safer place than apparel or home textiles, technical and industrial textiles are also attractive to foreign companies. In 2001, the trade deficit was \$1,266 million. This was a substantial increase from the \$463 million recorded in 1997, equivalent to a growth rate of 29% annually. (See Table 3.10)

Therefore, the development of the technical and industrial textile industry in the US must be underpinned by a number of key competitive advantages. These include:

- the size and cutting-edge nature of demand in the US market;
- the high quality of US textile engineers
- the technical strengths of supporting educational and research institutions,
- the technical and commercial strengths of suppliers, such as chemical and man-made fiber firms.

Utilizing these strengths will be a critical factor in determining the future success of the industry in the US.

Specific success factors include the following:

- High levels of investment in product innovation to develop high specification products of dependable quality and improved product solutions that could open-up new end-use segments. In particular, there is a need to understand and harness emerging product, process and business technologies.
- Investment in the development of close working relationships with customers to provide excellent service
- Investment in market research to identify opportunities and to determine how best to exploit them
- The active development of export markets.

As noted above, a number of factors could hinder successful development of the industry. Firstly, although the technical and industrial textile sector is less vulnerable than the apparel-related textile industry to global competition, it will nevertheless face growing competition from companies in developing and other industrialized countries. Secondly, there is a lack of information about market needs that obscures opportunities. Thirdly, there are high investment needs for new product development and/or alteration of production and distribution/ marketing set-ups. Finally, in some instances, there are difficulties of breaking into market segments where there are strong relationships between customers and suppliers.

5.2 Toward new definitions

The term *technical* is defined in the Oxford English Dictionary²⁶ as “pertaining to, involving or characteristics of a particular art, science, profession or occupation, or the applied arts and sciences generally”.

The term *industrial* is defined by the Oxford English Dictionary as “pertaining to the nature of industry or productive labor” a second definition is “material: of a quality suitable for industrial use”. In the same publication, *industry* is defined as “a particular form or branch of productive labor; a trade, a manufacture”.

Since the beginning of modern textile industry, industrial textiles have been considered as textiles that are used in industries other than apparel, home furnishings and floorcoverings. However, the definitions of industrial textiles does not satisfy the new term, *technical textiles*, because industrial textiles have been focused on production itself while technical textiles are more focused on the market activities

Therefore, technical textiles should be:

- activities of textiles in the industry including:
 - textile products as a raw materials that satisfy a quality suitable for a specific industrial use
 - textile products that add new functions or increase their own characteristics e.g. apparel with waterproofing, or floor coverings with flame retardant properties.

5.3 Classification of Technical Textiles

Kotler states that industrial goods can be classified in terms of how they enter the production process, and their relative costliness. Three groups of industrial goods are:

- Materials and component parts used in the manufacture of another product
- Capital items - including installations and equipment.
- Supplies and business services maintenance and repair items, and operating supplies

The major industries making-up the business market are agriculture, forestry and fisheries; mining; manufacturing; construction; transportation; communication; public utilities; banking, finance and insurance; distribution and services. (Kotler, P., *Marketing Management*. p216)⁶

Textile sectors are defined by activity, product and end use. For coherence they have to be reasonably discrete in order that they are measurable.

As described above, the recognition of technical textiles is more focused on the market rather than production of textiles. Thus, appropriate basis for grouping can be economic sector destinations while industrial textiles should be classified based on products, end-use application and their functions. However, the problem with technical textiles is that as a grouping of activities they are not discrete and easily measured. (See Table 5.2)

[Table 5.2] A Typology for classifying technical and industrial textiles

Raw Materials	Fiber	Cotton, wool etc	
	Process	Spinning, weaving, knitting, nonwovens	
Industrial Textiles	Products	Canvas, coated fabrics, sewing threads	
	End-use application	Sails, awnings, geotextiles, trunk liners	
	Function	Protection, filtration, reinforcement	
Technical Textiles	Economic sector destinations (customers)	Specific sector	Broad sector
		Horticulture	Agriculture
		Forestry	
		Fishing	
		Construction	Industry
		Food	
		Transportation	
		Mining	
		Furniture/ Furnishings	
		Machinery manufacturing	
		Medical/ Hospitality	Services
		Entertainments/ Events	
		Military	

References

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- ¹ Horrocks, A.R. and Anand, S., “*Handbook of Technical Textiles*”, Boca Raton [Fla.], CRC Press, Cambridge, England, Woodhead Pub. Ltd., in association with The Textile Institute, 2000.
- ² Adanur, S., “*Wellington Sears handbook of industrial textiles*”, Lancaster, PA, Technomic Publishing Co., Inc., 1995.
- ³ “*The world technical textile industry and its markets: prospects to 2005*”, A report prepared for Techtexil Messe Frankfurt, David Rigby Associates, Manchester, April 1997.
- ⁴ “*Fiber Organon* [serial]”, Roseland, N.J., Fiber Economics Bureau, Inc., 1989-2002.
- ⁵ US Bureau of the Census M3 series, cited in “*Textile Highlights*” ATMI, June 2002.
- ⁶ Kotler, P., “*Marketing Management*”, Upper Saddle River, N.J., Prentice Hall, 1991, p162, p196-197, p.216, p434.
- ⁷ Evans, J.R. and Berman, B., “*Marketing*”, 7th edition, Prentice Hall, Upper saddle River, NJ, 1997, p37.
- ⁸ Oliva, R., “*Business-to-Business Marketing Overview*”, The American Marketing Association
www.ama.org
- ⁹ Carmichael, W.L., Linton, G.E. & Price, I., “*Callaway Textile Dictionary*”, 1st edition, La Grange, Ga., Callaway Mills, 1947
- ¹⁰ Linton, G.E., “*The Modern Textile Dictionary*”, 3rd edition, New York, Duell, Sloan and Pearce, 1963.
- ¹¹ Svedova, J., “*Industrial Textiles - Textile science and technology, v. 9.*”, Amsterdam, New York, Elsevier, 1990, p13-26.
- ¹² McIntyre, J. E., Daniels, P. N. (Paul N.), and Textile Terms and Definitions Committee., “*Textile Terms and Definitions*”, 10th Ed, Manchester, UK, Textile Institute, 1995 p170.
- ¹³ Tortora, P.G. and Merkel, R.S., “*Fairchild’s Dictionary of Textiles*”, 7th edition, New York, Fairchild Publications, 1996.
- ¹⁴ “Textile” cited in the “*Britannica Student Encyclopedia*”
<http://search.eb.com/ebi/article?eu=299453&query=textiles%20in%20brazil>
- ¹⁵ The Industrial Fabrics Association International (IFAI)
<http://www.ifai.com/membership/divisions/index.php3>
- ¹⁶ “*Manufactured fiber handbook*”, Washington, DC, Fiber Economics Bureau, 2002.
- ¹⁷ “*Cotton counts its customers* [serial]”, Memphis, Tenn., Economic & Market Research Service, National Cotton Council of America.
- ¹⁸ Hermann, M., Standortsicherung in der Textil und Bekleidungsindustrie, Strategische Optionen für die Textil und Bekleidungsindustrie der Industrienationen vor dem Hintergrund steigender Importe und zunehmender Produktionverlagerungen in Niedriglohnländer, Frankfurt/M, 1996
- ¹⁹ “*Technical textiles and industrial nonwovens: world market forecast to 2010*”, David Rigby Associates, Manchester, June 2002
- ²⁰ Economic Census, US Census Bureau
<http://www.census.gov/prod/ec97/97m3132d.pdf>

<http://www.census.gov/prod/ec97/97m3149a.pdf>

<http://www.census.gov/prod/ec97/97m3149b.pdf>

<http://www.census.gov/prod/ec97/97m3149c.pdf>

<http://www.census.gov/prod/ec97/97m3149d.pdf>

<http://www.census.gov/prod/ec97/97m3149e.pdf>

²¹ Annual Survey of Manufactures, US Census Bureau

<http://www.census.gov/prod/2002pubs/m00as-1.pdf>

²² 1997 Economic Census, Material Summary, US Census Bureau

<http://www.census.gov/prod/ec97/97m31s-ms.pdf>

²³ “*Textile Organon* (later title: *Fiber Organon*) [serial]”, New York, Textile Economics Bureau, Inc., 1952-1989.

²⁴ Trade Statistics., International Trade Administration

http://www.ita.doc.gov/td/industry/otea/usito98/tables_naics.htm

²⁵ Chang, w. and Kilduff, P., “*US Market for Technical Textiles.*”, Small Business & Technology Development Center, May 2002

<http://www.sbt dc.org/research/textiles.pdf>

²⁶ Oxford English Dictionary. searched electronically from www.oed.com

Appendices

A. *The Modern Textile Dictionary*¹⁰ by George E. Linton, Ph. D.

Industrial and mechanical fabrics

For the laundry supply trade

Laundry apron ducks	36" – 3.50 sheeting for ironing boards
Laundry nets and tubing	40" – 3.15 sheeting for ironing boards
Roll cover duck	
Roll cover sheeting	

For the Converting Trade

Army duck, waterproofed for various purpose	Sateens
Drills	Sheeting
Enameling duck – 38" to 100" inclusive	Single and double filling duck
Gabardine	Twills
Moleskin	Wagon cover duck
	Wide duck, waterproofed
	Printed cloth

For Dry Goods Jobbers and Chain Stores

Crash	Single filling duck
Denim	Turkish toweling
Double filling duck	Wide duck
Huck toweling	30" – 2.50 – 2.85 drill
Print cloth	

The Application of Industrial and Mechanical Fabrics.

1. For the mechanical rubber trade

Army duck	Lawn cloths
Balloon fabrics	Leno or doup fabrics

Belting duck Bootleg duck Chafer fabric Drills and twills, wide Enameling duck Hose duck	Napped fabrics Osnaburgs Sateens Sheeting, narrow and wide Tire fabrics
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2. For the Rubber, Oilcloth, and Pyroxylin Trade

Wide drills and twills Wide moleskins – Chafer Wide print cloths	Wide sateens and broken twills Wide sheeting
--	---

3. For the shoe Trade

37" army duck 37" drills 37" four-leaf twills	Enameling duck 30" gem duck leno or doup specialties
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4. For the use of Filtering Media – Chemical and Paint manufacturers, oil refiners, soap manufacturers, sugar refiners, etc

Chain cloth Duck	Drills Twills
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5. For the Laundry supply trade

Laundry apron ducks Laundry nets and tubing Roll cover duck Roll cover sheeting	36" – 3.50 sheeting for ironing boards 40" – 3.15 sheeting for ironing boards
--	--

6. For the Converting trade

Army duck, waterproofed for various purpose Drills Enameling duck – 38" to 100" inclusive Gabardine Moleskin	Sateens Sheeting Single and double filling duck Twills Wagon cover duck Wide duck, waterproofed
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	Printed cloth
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7. For the tent and awning trade

Army duck	Numbered duck
Awning stripe	Single filling duck
Double filling duck	Tent twill
Mineral khaki duck	Waterproof duck

8. For specialty manufacturers

Advertising specialties – duck, drill, print cloth, sheeting	Napped fabrics
Fireproof material	Vat dyed fabrics
Golf bag duck	Window shades – sheeting, print cloth, enameling duck

9. For the dry goods, jobbing and chain-store trade

Crash	Single filling duck
Denim	Turkish toweling
Double filling duck	Wide duck
Huck toweling	30” – 2.50 – 2.85 drill
Print cloth	
Unbleached sheeting, 36” to 40” in standard constructions, as follow	
36” – 3.50-64*68	36” – 5.00-48*48
36” – 3.75-64*64	36” – 5.50-44*44
36” – 4.00-56*60	36” – 6.50-40*40
36” – 4.25-56*52	40” – 3.15-64*68
36” – 4.50-56*52	40” – 3.60-56*60
36” – 4.70-48*52	

10. For Flag manufacturers

Bunting:	Single filling duck
Government type – all wool	Print cloth
Navy type – all wool	30” – 2.50 and 2.85 drill
Commercial – all cotton	
Sheeting	

11. For fabrics used for clothing and work-clothing trade

Army duck In plain and water repellent finish	Gary drill, duck, twill
Bedford cord, gabardine, jean, moleskin, sateen, suede, suiting fabric	Indigo blue denim
Corduroys for men's wear and women's wear	Khakis, drapery fabrics, drill, herringbone, jean, twill, upholstery fabric
Express, hickory, and fancy stripes	Single filling and double filling duck

12. Miscellaneous Industries

Adhasive industry: drill, jean, double, filling duck
Airplane and balloon: balloon fabric, wing fabric
Army and navy:
Boat covers – army duck, numbered duck, paulins
Gun covers – army duck
Tents – army duck, shelter tent duck
Wagon and truck covers – numbered duck
Automobile industry: headlinings: broken twill, sateen, sheeting
Bakelite and synthetic resin: duck
Buffing wheel manufacturers: naught duck and sheeting
Railroads: cap curtains and ceilings for refrigerator cars use numbered duck
Shipping covers: fabric to suit particular use
Spring covers: double filling duck
Upholstery padding: sheeting

B. Technical and Industrial Textile Markets, End-Uses, Applications and Products

[Table B.1] List of technical and industrial textile markets, end-uses, applications and products, as defined by David Rigby Associates

Designation	End-Uses	Applications	Product Included
Agrotech	Agriculture, Horticulture Forestry and Fishing	Cover, Protection, Collection	Woven, nonwoven covers, netting, crop cover, capillary matting
		Fishing	Fishing ropes, fishline, fishing nets
		Tying	Baler twine
Buildtech	Building and Construction	Protection, Display	Tarpaulins, hoardings, scaffold nets
		Textile Constructions	Textile construction, awnings
		Building Components	Roof scrims, Housewrap, shingles, roofing felts, woven roofing fabrics
		Reinforcements	Concrete reinforcement, composites
Clothtech	Technical Components of Shoes and Clothing	Shoe Components	Shoe laces, shoe components
		Insulation, Structure	Interlinings, woven; Interlinings, nonwoven, waddings
		Sewing Products	Sewing threads, labels, fasteners (Zips, Velcro)
Geotech	Geotextiles, Civil Engineering	Stabilization, Separation, Drainage	Ground stabilization
		Soil Reinforcement	Soil reinforcement
		Erosion Control	Erosion control
		Linings	Pit linings
Hometech	Components of Furniture, Household Textiles and Floorcoverings	Carpet Components	Woven carpet backings, nonwoven carpet backings, carpet ground yarns
		Furniture Components	Spring wrap/insulators, fiberfill, webbings, mattress components, curtain tapes, platform cloths, dust cloths, thread
		Cleaning, Filtration	Cleaning materials - woven , nonwoven, nonwoven vacuum filters, HVAC filters
		Tickings	Mattress tickings, pillow tickings
		Composites	Composites
Indutech	Filtration, Cleaning & Other Industrial	Filtration	Filters: woven, HEPA, nonwoven dust, nonwoven liquid, cigarette;

	Materials		papermaking felts
		MRGs	Conveyor belt, hoses, drive belting
		Cleaning	Abrasives, brushes, woven wipes, nonwoven wipes
		Lifting, Pulling	Lifting webs, ropes
		Electrical Components	Cable components, Electrical composites, battery separator, etc
		Other	Seal/gaskets, other coated fabrics, fiberfill, other composites
Medtech	Hygiene and Medical	Cleaning	Wipes, cotton wool
		Coverstock	Coverstock
		Woundcare	Woven, nonwoven woundcare, sterile packaging
		Protection	Gowns, drapes, medical mattresses
Mobiltech	Automotive, Marine, Railways and Aerospace	MRGs	Tire cord, hose, belts
		Safety	Seat belts, air bags
		Trim, Insulation	Upholstery, trim, insulation
		Floorcovering	Carpets, backing
		Protection	Tarpaulins, tie downs
		Composites	Composites
		Other	Filters, ropes
Packtech	Packaging	Bulk Packaging	FIBCs, sacks
		Disposable	Teabags, food-soaker pads, performance envelopes, other nonwovens
		Tying	Twine, string (non-baler)
		Other	Netting, other woven strapping, etc
Protech	Personal and Property Protection	Particulate Protection	Dust, asbestos protection, face masks, clean room
		Chemical Protection	Curable and disposable chemical protection, NEC
		Flame Retardant	Heat, fire resistant
		Cut Resistant	Anti-ballistic, cut resistant
		Outdoor Use	Foul weather clothing, hi-visibility garments
		Other	Safety straps (excel car seat belts)
Sporttech	Sport and Leisure Equipment	Luggage Components	Sports bags/straps. Textile shopping bags, substrates for leathergoods

		Sports Equipment	Net, balls, ropes, artificial turf, composites, sports ropes, sail cloth, airsport fabrics, animal webbing
		Camping Equipment	Tents, sleeping bags
		Other	Flags, bookcloth, boat covers
Oekotech	Environmental protection	Products extracted from the above	Housewrap (Buildtech), erosion control, pit linings (Geotextiles), woven filters, nonwoven dust filters (indutech), insulation (Mobiltech)

Source: Techtexil/ David Rigby Associates¹⁸

C. Bridge between NAICS and SIC Manufacturing

[Table C.1] Bridge Between NAICS and SIC Manufacturing

NAICS	Manufacturing Sector	SIC	Manufacturing Sector
31323	Nonwoven fabric mills	2297	Nonwoven fabrics
		2299	Textile goods, n.e.c.
314911	Textile bag mills	2392	Housefurnishings, n.e.c.
		2393	Textile bags
314912	Canvas & related product mills	2394	Canvas & related products
314991	Rope, cordage & twine mills	2298	Cordage & twine
314992	Tire cord & tire fabric mills	2296	Tire cord & fabric
314999	All other miscellaneous textile product mills	2299	Textile goods, n.e.c.
		2395	Pleating & stitching
		2396	Automotive & apparel trimmings
		2399	Fabricated textile products, n.e.c.
		3999	Manufacturing industries, n.e.c.

Source: 1997 Economic Census, Bridge between NAICS and SIC, US Census Bureauⁱ

ⁱ 1997 Economic Census, Bridge between NAICS and SIC, US Census Bureau

<http://www.census.gov/epcd/ec97brdg/INDXNAI3.HTM#31-33>

D. Textile material consumption in Industry

[Table D.1] Textile material consumption in industry (Thousand Dollars)

NAICS	Industry	NAICS	Form of textile products	1997
311	Food MFG	31491101	Bags, textile (burlap, cotton, polypropylene, etc)	61,072
316	Leather & allied product mfg	31320003	Textile Fabrics	73,108
		31332001	Plastic coated, impregnated or laminated fabric	122,547
		31321023	Broadwoven fabric (piece goods)	118,760
321	Wood product mfg	31411001	Floor coverings, textile	207,509
322	Paper mfg	31323001	Nonwoven fabrics	644,520
		31332007	Coated or laminated fabrics, including vinyl coated	209,928
323	Printing & related support activities	31320001	Cloth & nonwoven fabrics for hardbound book covers	82,920
		31321003	Cotton broadwoven fabrics (piece goods)	33,286
		31321013	Polyester broadwoven fabrics (piece goods)	10,520
		31321009	Rayon & acetate broadwoven fabrics (piece goods)	D
		31321021	Other broadwoven fabrics (piece goods)	5,308
		31322103	Narrow fabrics (12 inches or less in width)	D
		31311003	Yarn, all fiber	2,497
		31332001	Plastic coated, impregnated or laminated fabric	S
		31332005	Coated or impregnated woven & nonwoven fabrics, except rubberized	29,982
326	Plastic & rubber products mfg	31321017	Broadwoven fabrics	148,745
		31499201	Nylon tire cord	221,137

		31499203	Polyester tire cord	392,228
		31499205	Metallic tire cord	424,381
		31499207	All tire fabrics and rayon, fiberglass, chafer and other tire cord	193,309
		31320003	Textile Fabrics	263,850
		31320013	Cotton Fabrics	35,669
		31320015	Manmade fiber fabrics including glass	161,871
327	Nonmetallic mineral products mfg	31320005	Cotton and manmade fiber fabrics, broadwoven and narrow woven	169,485
331	Primary metal mfg	31311103	Cotton yarns	D
335	Electric equipment, appliance & component mfg	31311103	Cotton yarns	15,649
336	Transportation equipment mfg	31411003	Carpeting	718,158
		31412100	Curtain & draperies	72,740
		31321013	Polyester broadwoven fabrics (piece goods)	194,831
		31321003	Cotton broadwoven fabrics (piece goods)	D
		31321009	Rayon & acetate broadwoven fabrics (piece goods)	D
		31321021	Other broadwoven fabrics (piece goods)	704,518
		31322103	Narrow fabrics (12 inches or less in width)	D
		31311003	Yarn, all fiber	10,604
		31332001	Plastic coated, impregnated or laminated fabric	773,140
		31491200	Canvas products	29,479
337	Furniture & related product mfg	31321007	Broadwoven cotton upholstery fabric excluding ticking	355,785
		31321011	Other woven upholstery fabric (rayon, nylon polyester, etc) excluding ticking	501,040
		31499901	Padding, batting and filling except rubber and plastic form	202,468
		31332007	Coated or laminated fabrics, including vinyl coated	606,738
		31320027	Fabrics, all type	84,588

		31321019	Uncoated broadwoven fabric for upholstery	170,105
		31320011	Woven upholstery fabrics (cotton, nylon, polyester, rayon, etc) excluding ticking	43,426
		31321005	Ticking (mattress)	256,731
		31332003	Plastic coated fabrics & shade cloth	173,461
		31499100	Cordage	18,121
339	Miscellaneous mfg			
339112	Surgical & medical instrument mfg	31323001	Nonwoven fabrics	17,445
		31321025	Broadwoven fabrics	19,328
339113	Surgical appliance & supplies mfg	31323001	Nonwoven fabrics	329,109
		31321025	Broadwoven fabrics	204,363
339920	Sporting & athletic goods mfg	31320007	Cotton, wool, manmade fiber fabrics	98,397
339931	Doll & stuffed toy mfg	31321023	Broadwoven fabrics (piece good)	15,297
339932	Game, toy, & children's vehicle mfg	31321023	Broadwoven fabrics (piece good)	22,686
339942	Lead pencil & art goods mfg	31321019	Uncoated broadwoven fabric for upholstery	D
339944	Carbon paper & linked ribbon mfg	31320003	Textile Fabrics	12,259
339950	Sign mfg	31300045	Textiles & fabrics	20,305
339993	Fastener, button, needle & pin mfg	31320005	Cotton & manmade fiber fabrics, broadwoven & narrow woven	38,866
339994	Broom, brush & mop mfg	313000001	Yarn & textiles made of cotton, wool, silk and manmade fibers	151,371
339995	Burial casket mfg	31320007	Cotton, wool, manmade fiber fabrics, etc	52,343

Source: 1997 Economic Census, Material Summary, US Census Bureau²¹

E. Estimated Consumption of Technical and Industrial Textiles

[Table E.1] Estimated Consumption of Technical and Industrial Textiles in the US and Canada by Volume 1995-2005. (Million Pounds)

	1985	1990	1995	2000	2005	% 85-95	% 95-05
Agrotech	293	306	331	351	370	1.2	1.1
Buildtech	679	759	893	1,010	1,164	2.8	2.7
Clothtech	311	293	388	362	340	2.2	-1.3
Geotech	84	148	185	256	315	8.2	5.4
Homotech	794	953	1,222	1,486	1,738	4.4	3.6
Indutech	833	999	1,200	1,402	1,629	3.7	3.1
Medtech	578	781	811	856	902	3.5	1.1
Mobiltech	1,021	1,072	1,169	1,263	1,396	1.4	1.8
Oekotech	73	93	123	159	198	5.3	4.9
Packtech	170	227	262	295	340	4.4	2.6
Protech	46	82	99	117	135	7.8	3
Sporttech	128	168	181	203	240	3.5	2.9
Total	4,939	5,788	6,741	7,598	8,569	3.2	2.4

Source: Techtexil/ David Rigby Associates³

[Table E.2] Estimated Consumption of Technical and Industrial Textiles in the US and Canada by Value 1995-2005. (Millions US Dollars)

	1985	1990	1995	2000	2005	% 85-95	% 95-05
Agrotech	520	550	590	624	663	1.3	1.2
Buildtech	831	979	1,147	1,319	1,551	3.3	3.1
Clothtech	1,251	1,147	1,485	1,369	1,287	1.7	-1.4
Geotech	180	312	389	538	659	8.0	5.4
Homotech	1,613	1,914	2,443	2,914	3,385	4.2	3.3
Indutech	1,836	2,147	2,579	3,017	3,543	3.5	3.2
Medtech	1,316	1,997	2,021	2,163	2,276	4.0	1.2
Mobiltech	2,88	3,062	3,139	3,361	3,612	1.2	1.4
Oekotech	219	249	312	383	458	3.6	3.9
Packtech	319	444	524	600	700	5.1	2.9
Protech	198	349	435	522	620	8.2	3.6
Sporttech	386	480	513	555	628	2.9	2.0
Total	11,281	13,381	15,264	16,982	18,923	3.1	2.2

Source: Techtexil/ David Rigby Associates³