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Reverse architecting conventional footwear. Towards an A3 Architecture Overview that supports development of alternative footwear architectures.

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Abstract. The architecture of contemporary footwear is the result of a long history of footwear development. In this history, part of the argumentation behind the architecture has been lost, causing footwear developers to make decisions based on habits and badly underpinned assumptions. New insights on the negative influence of most conventional footwear on human (foot) health and the design freedom that arises from modern manufacturing techniques, create the urge to reconsider the common way of developing. By reverse architecting conventional footwear, this paper derives an A3 Architecture Overview of conventional footwear. In the future this overview should provide a tool for enabling product evolution towards healthy footwear, by allowing developers to consciously and purposefully deviate from ‘the standard architecture’ while taking into account the consequences of design decisions they make. The approach that is described in this paper is also applicable to the development of architecture overviews for other product families.

Background

In the Western world, footwear is so commonly used that it has become inherently part of our being in the world. It is via footwear that users are in almost constant contact with different types of environments. While serving as an extension of the human body, the earliest footwear seems to merely have had a protective function (Stewart 1972; Swallow 1987). Nowadays, footwear developers have succeeded to include many more functionalities. These functionalities, however, often partly – or even entirely – show a mismatch with the functions of the human body. Footwear developers mistakenly see the foot as an inflexible lever which is fragile and thus needs to be supported and packaged (Robbins & Hanna 1987). Instead of preserving healthy feet, this can have many adverse short- and long-term effects; the natural shape of the foot can be deformed, loading in the joints can be changed, plantar sensation can be reduced, the foot-strike pattern can be altered, the foot-strength and elastic energy storage can be reduced, evaporation of perspiration can be reduced and the maturation of the foot can be hampered, ultimately resulting in pain, reduced mobility and high societal costs (Buldt & Menz 2018; D’Août et al. 2009; Frey 2000; Lieberman et al. 2010; Perl, Daoud & Lieberman 2012; Rose et al. 2011).

Considering those insights, together with the newly obtained design freedom that results from the emergence of modern manufacturing techniques, the common way of developing footwear might unintentionally inhibit footwear developers to use the full potential of knowledge and technology at hand. To support design efforts towards creating product evolutions, first the architecture of present

footwear has to be documented. Reverse architecting using the so-called A3 Architecture Overview (A3AO) – containing a physical view (showing design decisions), a functional view (providing design argumentation) and a quantification view (providing key-drivers) – can be employed for that purpose (Borches 2010). The aim of this paper is, therefore, to derive an A3AO for footwear development by reverse architecting conventional footwear. In the future, this A3AO should provide a tool for enabling product evolution towards healthy footwear by allowing footwear developers to consciously and purposefully deviate from ‘the standard architecture’, while constantly allowing them to consider the consequences of the design decisions they make.

Methods

In reverse architecting, usually three different process phases, being Information Extraction, Abstraction, and Presentation are executed in an iterative manner (Müller, Wong & Tilley 1995). In reverse architecting conventional footwear, also these three phases are executed. The information extraction phase is executed by analyzing descriptions - that are used by academics as well as in industry - in relation to the parts of non-athletic (men’s and women’s) footwear as well as athletic footwear. The phase results in an overview of the components of different types of footwear as well as the functions thereof. By comparing the components and functions and by boiling down to the basic elements during the abstraction phase, both a physical description and a functional description is made that is common for most conventional types of footwear. Together with a shortlist of the key-drivers (Bonnema 2008; Heemels et al. 2006) that represent the high-level requirements of specific footwear (quantification view), these provide the views to be presented in an A3 Architecture overview for conventional footwear (presentation phase).

The physical and functional descriptions are evaluated by analyzing a number of random pictures showing footwear anatomy and by iteratively comparing the represented parts / terms with the results until then. The parts and functions that are still lacking can subsequently be included in the final physical and functional view on the A3 Architecture Overview (see Figure 1).

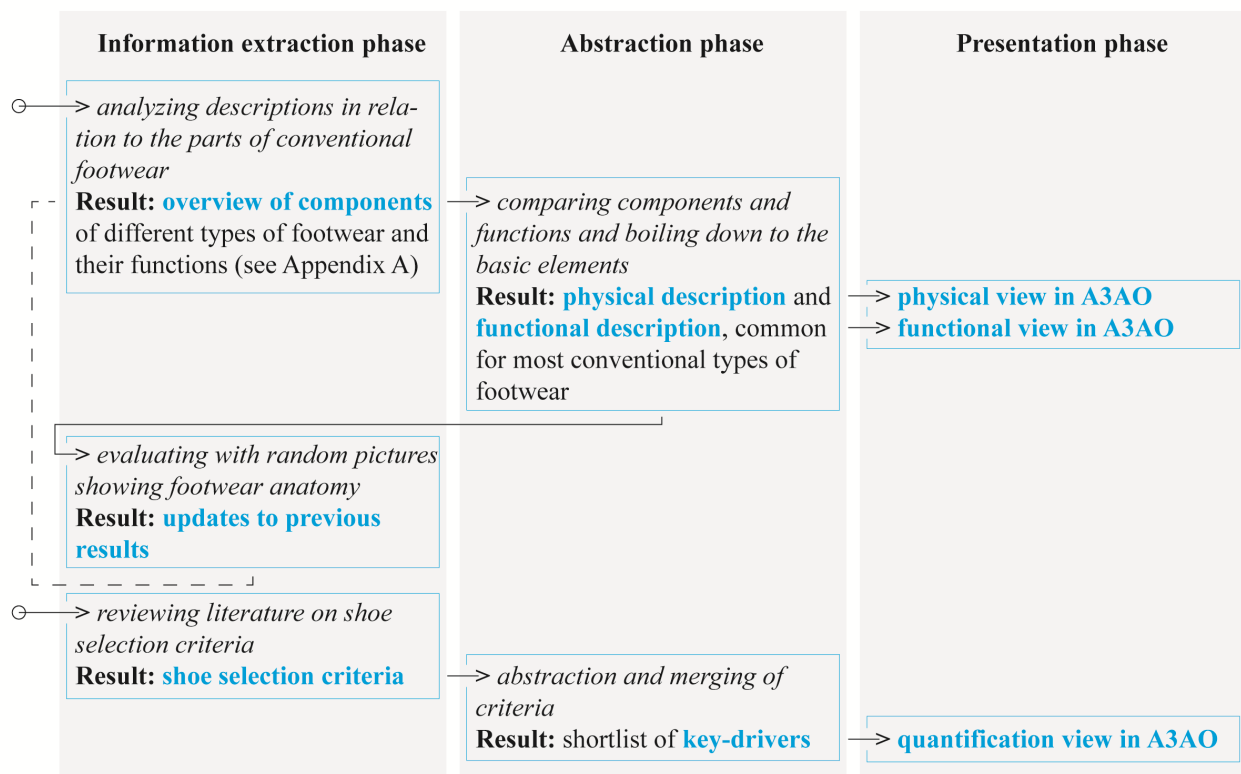


Figure 1. Schematic representation of research flow.

Physical View

To create a better understanding of the architecture(s) of conventional footwear, first an overview (table) has been made of the terminology related to the functional parts of conventional footwear (Appendix A). The appendix is organized per sub-assembly of the shoe (shaded rows). The parts of each assembly are organized in individual rows; sub-parts are indented. As conventional footwear comes in many different appearances, dependent on the purposes it is used for, the overview makes a distinction between non-athletic footwear (source columns 1 and 3) and athletic footwear (source columns 2 and 4); those types of footwear show a relatively large difference in the materials, components and manufacturing techniques that are used (McPoil Jr 1988). Where athletic footwear is largely the same for both men and women, non-athletic footwear shows some differences in this respect. These differences, however, mainly concern the geometry of parts that are used. Therefore, the overview does not have to make a specific distinction in this respect.

The sources that have been used to create the overview were selected to vary both in academic (source columns 1 and 2) and industrial (source columns 3 and 4) nature. This was done to investigate whether there is any difference in the use of terminology between the two. The distinction is also visible in the columns of the table. An initial number of resources was selected to start with ((Blazer, Jamrog & Schnack 2018; Luximon & Khandual 2018; McPoil Jr 1988; McPoil 2000) that represent the academic viewpoint, and (C&E_Fashions 2019; Motawi 2015) that represent the industry viewpoint). From the sources, quotations were collected in which terminology related to the functional parts of footwear was used. This terminology was underlined, and the citations were structured based on these terms (rows in table Appendix A). When different terms were considered to address a similar part, these terms are presented in the same row. It is important to note that this does not imply that the terms are full synonyms. In the attempt to complement the overview, a number of additional resources (BootMoodFoot 2019; Davis 2014; Kippen 2009; Kurcina 2017; Muzquiz 2017; Pelizzari 2013; Ramsey et al. 2019; Runner'sWorld 2009; ShoeGuide 2019; Wong & Luximon 2013) was added.

Eventually, a number of fields in the table (in appendix A) remained empty. These empty fields can be explained by the different architectures of non-athletic and athletic footwear as well as the lacking need for academics to address the terminology related to specific (sub)parts of an assembly.

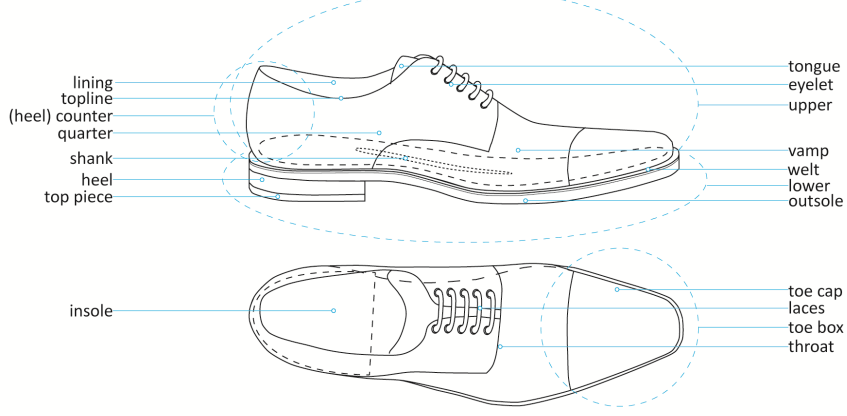
The terminology was eventually used to create the physical description of conventional (non-athletic and athletic) footwear presented in Figure 2. When multiple terms were mentioned in the same row of the table, a general term was selected to be used for the physical description. An additional description of a non-athletic women's pump was added to show the large overlap in terminology with non-athletic men's footwear while having a complete different appearance; the represented shoe style ('pump') merely consists of fewer parts and has only one term (platform) that is specific for this type of shoe. It should be noted that Figure 2 gives a simplified representation of all parts (and corresponding terminology); for a full overview of all terminology, Appendix A should be referred to.

In each quotation presented in the overview in Appendix A, a possible description of the function of the part at hand was made *italic*. The *italic* descriptions of functions were used to derive the functions of conventional footwear in the next section.

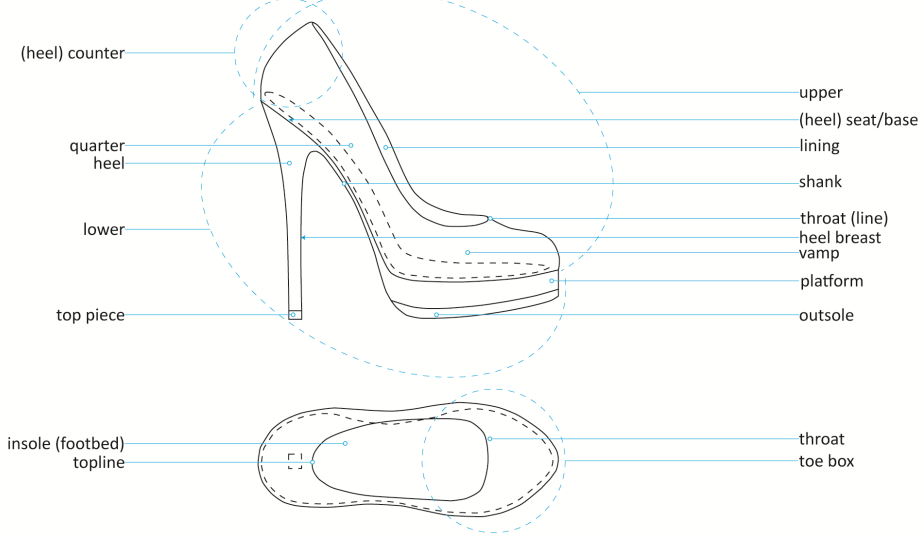
Functional View

To derive the functions that are general for most types of conventional footwear, the terminology from the physical view was used and the *italic* function descriptions (see Appendix A) were listed together with these terms. In making Table 1, the function descriptions were rephrased by using terms from the 'Functional basis reconciled function set' defined by the National Institute of Standards and Technology, NIST (Hirtz et al. 2002). This was done with the aim to boil down to a limited and uncluttered set of different functions per part, that adheres to accepted terminology.

NON-ATHLETIC MEN'S FOOTWEAR



NON-ATHLETIC WOMEN'S FOOTWEAR



ATHLETIC FOOTWEAR

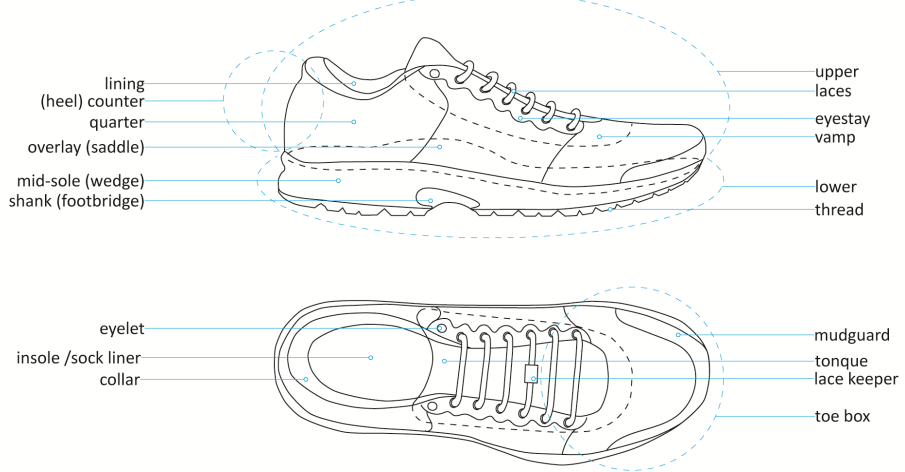


Figure 2. Physical View: Men's and women's non-athletic and athletic footwear

Table 1: Derived functions of conventional footwear

Component	Function(s)
Upper	
Upper	<ul style="list-style-type: none"> - Enclose top of foot (Khan, Jacobs & Ashbaugh 2013; Runner'sWorld 2009; ShoeGuide 2019) - Enclose sides of the foot (Khan, Jacobs & Ashbaugh 2013; Runner'sWorld 2009; ShoeGuide 2019) - Regulate temperature (BootMoodFoot 2019; Khan, Jacobs & Ashbaugh 2013; Runner'sWorld 2009) - Limit wear (shoe) (Khan, Jacobs & Ashbaugh 2013) - Protect foot against moisture (Khan, Jacobs & Ashbaugh 2013) - Condition cleanliness (Khan, Jacobs & Ashbaugh 2013) - Secure to foot (Runner'sWorld 2009) - Protect foot (BootMoodFoot 2019)
Vamp	<ul style="list-style-type: none"> - Enclose forefoot (McPoil Jr 1988) - Feel comfortable (to the skin) (McPoil Jr 1988) - Limit wear (shoe) (BootMoodFoot 2019) - Regulate /maintain temperature (Motawi 2015)
Toe-box/ toe cap	<ul style="list-style-type: none"> - Maintain shape (shoe) (Blazer, Jamrog & Schnack 2018; Luximon & Khandual 2018) - Enclose toes (McPoil Jr 1988) - Display personality (McPoil Jr 1988; Motawi 2015) - Protect the foot (ShoeGuide 2019) - Limit wear (shoe) (Muzquiz 2017; ShoeGuide 2019)
<u>Mudguard</u>	<ul style="list-style-type: none"> - <u>Limit wear (shoe) (Kurcina 2017)</u>
Throat line	<ul style="list-style-type: none"> - Secure to the foot / Detach from the foot (Kippen 2009) - Guide foot into shoe (Kippen 2009)
Tongue	<ul style="list-style-type: none"> - Distribute pressure (Khan, Jacobs & Ashbaugh 2013; Motawi 2015; Muzquiz 2017) - Limit dirt entry (BootMoodFoot 2019)
Eye-stay	<ul style="list-style-type: none"> - Locate eyelets/webbings for lacing (shoe) (Motawi 2015)
Laces	<ul style="list-style-type: none"> - Secure to the foot / Detach from the foot (BootMoodFoot 2019; McPoil 2000) - Adjust fit (shoe) (BootMoodFoot 2019)
Quarter/ shaft	<ul style="list-style-type: none"> - Enclose back of the foot (BootMoodFoot 2019) - Enclose ankles, calf, and leg (BootMoodFoot 2019)
Overlay/ saddle	<ul style="list-style-type: none"> - Maintain shape (shoe) (Runner'sWorld 2009) - Secure midfoot (Runner'sWorld 2009) - Support arch (Runner'sWorld 2009)
Heel counter	<ul style="list-style-type: none"> - Stabilize hindfoot / secure heel (Blazer, Jamrog & Schnack 2018; McPoil Jr 1988) - Maintain shape (shoe) (BootMoodFoot 2019; Luximon & Khandual 2018; ShoeGuide 2019) - Stabilize foot (Muzquiz 2017) - Constrain motion (Kippen 2009)
Topline/ collar	<ul style="list-style-type: none"> - Limit dirt entry (McPoil Jr 1988; Runner'sWorld 2009) - Feel comfortable (to the skin) (Khan, Jacobs & Ashbaugh 2013)
Eyelets	Guide laces (shoe) (Muzquiz 2017)
Linings	<ul style="list-style-type: none"> - Feel comfortable (to the skin) (Kippen 2009; ShoeGuide 2019) - Limit wear (shoe) (Kippen 2009; ShoeGuide 2019)
Welt/ feather	<ul style="list-style-type: none"> - Join parts (shoe) (BootMoodFoot 2019; Muzquiz 2017; ShoeGuide 2019)

Component	Function(s)
Lower	
Outsole	<ul style="list-style-type: none"> - Protect foot (McPoil Jr 1988) - Protect foot against frictional forces (Blazer, Jamrog & Schnack 2018) - Protect foot against moisture (Kippen 2009) - Transmit force (Blazer, Jamrog & Schnack 2018; Khan, Jacobs & Ashbaugh 2013; Kippen 2009; Motawi 2015) - Reduce shocks (Khan, Jacobs & Ashbaugh 2013; Runner'sWorld 2009) - Support foot (Runner'sWorld 2009) - Limit wear (shoe) (Khan, Jacobs & Ashbaugh 2013; Kippen 2009) - Limit torsion (shoe) (Khan, Jacobs & Ashbaugh 2013) - Allow flexion (shoe) (Khan, Jacobs & Ashbaugh 2013)
Tread	<ul style="list-style-type: none"> - Transmit force (McPoil Jr 1988; Runner'sWorld 2009) - Reduce shocks (McPoil Jr 1988; Runner'sWorld 2009)
Midsole	<ul style="list-style-type: none"> - Protect foot (Davis 2014) - Reduce shocks (C&E_Fashions 2019; Davis 2014; Khan, Jacobs & Ashbaugh 2013; Motawi 2015) - Stabilize foot (Khan, Jacobs & Ashbaugh 2013) - Enclose foot (Motawi 2015) - Feel comfortable (Motawi 2015) - Support foot (Motawi 2015)
Midsole wedge	<ul style="list-style-type: none"> - Increase angle (Khan, Jacobs & Ashbaugh 2013; Wong & Luximon 2013) - Reduce shocks (Khan, Jacobs & Ashbaugh 2013; McPoil Jr 1988) - Stabilize foot (Khan, Jacobs & Ashbaugh 2013; McPoil Jr 1988)
Insole (board)/ foodbed	<ul style="list-style-type: none"> - Provide template (shoe-fitting) (Blazer, Jamrog & Schnack 2018) - Maintain shape (shoe) (Motawi 2015) - Reduce shocks (Motawi 2015)
Shank/ footbridge	<ul style="list-style-type: none"> - Limit torsion (shoe) (McPoil Jr 1988; Runner'sWorld 2009) - Control flexion (shoe) (McPoil Jr 1988; Runner'sWorld 2009) - Limit flexion zone (shoe) (McPoil Jr 1988) - Stabilize foot (Ramsey et al. 2019) - Limit wear (shoe) (C&E_Fashions 2019) - Support foot (C&E_Fashions 2019; Runner'sWorld 2009) - Constrain motion (Kippen 2009)
Heel	<ul style="list-style-type: none"> - Display personality (McPoil Jr 1988) - Reduce shocks (C&E_Fashions 2019) - Increase height / provide heel lift (ShoeGuide 2019)
Top piece	<ul style="list-style-type: none"> - Limit wear (shoe) (Muzquiz 2017)
Heel seat	<ul style="list-style-type: none"> - Enclose heel (upper shoe) (ShoeGuide 2019)
Platform	<ul style="list-style-type: none"> - Increase height (Wong & Luximon 2013)
Assembly	
Stitching/ glue/ nails	<ul style="list-style-type: none"> - Join parts (shoe). (see Evaluation section)

Eventually a general list of possible footwear functions was derived by combining the functions from Table 1 and by removing the duplicates (see Table 2).

Table 2: Functional View: Functions of conventional footwear

Functions of conventional footwear	
- Secure to foot (secure mid foot, secure heel, ...)	- Adjust fit (shoe)
- Detach from the foot	- Maintain shape (shoe)
- Protect foot/body (frictional forces, moisture,...)	- Support foot (arch, ...)
- Enclose foot (optional: ankles, calf and leg)	- Stabilize foot/body
- Guide foot into shoe	- Constrain motion
- Transmit force (foot to ground)	- Reduce shocks
- Regulate temperature (foot)	- Increase height
- Display personality	- Increase angle
- Distribute pressure	- Limit torsion (shoe)
- Limit dirt entry	- Control flexion / limit flexion zone (shoe)
- Feel comfortable (to the skin) (shoe)	- Locate eyelets / webbings for lacing (shoe)
- Limit wear (shoe)	- Guide laces (shoe)
- Condition cleanliness (shoe)	- Join parts (shoe)
- Provide template (shoe-fitting)	

Quantification View

To define the quantification view, again the three reverse architecting phases were executed (Müller, Wong & Tilley 1995). As the quantification view was not really focused on in this phase of the research, this was done in a quick manner. First, information was extracted by reviewing literature on shoe selection criteria (Enke, Laskowski & Thomsen 2009; Goonetilleke & Luximon 2001; Miller 1976). The following shoe-selection criteria were mentioned: Arch type, Shoe design, Color, Appearance, Cost, Brand, Comfort, Fit (Enke, Laskowski & Thomsen 2009); Fashion, Price, Comfort, Fit, Performance, Durability (Miller 1976); Size, Shape, Flexibility, Style, Weight, Inside shoe climate, Materials, Tread, Cushioning (Goonetilleke & Luximon 2001). It is interesting that ‘healthfulness’ is not mentioned by these sources as a selection criteria. Recent insights into the negative influence of most conventional footwear on human (foot) health (Buldt & Menz 2018; D’Août et al. 2009; Frey 2000; Lieberman et al. 2010; Perl, Daoud & Lieberman 2012; Rose et al. 2011), however, might cause healthfulness to become a key-driver. Therefore, this term was also included in the overall list.

Abstraction and merging of the criteria eventually lead to the following shortlist of key-drivers that, for now, establish the quantification view:

- Price
- Comfort
- Appearance
- Durability
- Performance
- *Healthfulness*

Together, these key-drivers represent the interests of the end user. We need to expand and update the set to also include interests of other stakeholders, like the producer and store operator.

Evaluation

To evaluate both the physical and functional overviews that were established, first a number of pictures of footwear anatomy was randomly collected via Pinterest (see Figure 3) and the used terminology was compared with the overviews in Appendix A and Figure 3.

The comparison lead to the following list of parts that were not yet described:

- Toe burst panel; A part that is used to reduce wear to the upper caused by the toes/nails. The function of the toe burst panel can also be fulfilled by the toe-box/toe cap or mudguard.
- Mustache; A part with a mustache shaped pattern, added on the outside of the quarter, at the back, above the counter. The function of the mustache is similar to that of the counter and is used in classic sneakers.
- Lace-tip: The strengthened tip(s) of the laces. The tips allowing for easy pushing/pulling the laces through the eyelets.
- Bumper: The rubber strip attached to the forward facing part of a sneaker sole. The function is to decrease wear to the front of the sole.
- Foxing: The term foxing is used for almost any additional piece of leather/fabric attached to the outside of the vamp/quarter to add additional strength or to reduce wear, similar to an 'overlay'.
- Back-strap/rear-strap: The loop that is attached to the back of the quarter, sometimes as an extension of the back-stay. It can be used for easy shoe-access and prevents the back of the quarter from being suppressed.
- Back-tab: A different word for Achilles tendon protector.
- Air (or gel) Unit: An air (or gel) chamber added to the midsole for additional suspension.
- Insertor support / support insert: An insert in the midsole for additional support / to constrain motion.
- Rearfoot stabilizer: a support insert in the heel part of the midsole, to stabilize the rearfoot.
- Stitching / glue / nails: The materials used to assemble all different parts together.



Figure 3. Overview of images showing footwear anatomy.

(Derived from <https://pin.it/<xyz>> ; where <xyz>: 1=5qovk6xb12m7qp 2=anfqxi33logo3 3=44dusbaomfskds 4=jlj2vb3djw6koz 5=lgbczugnegwzg4 6=xatpu6ble5z4pz 7=d27j5yfsfpqdfd 8=vajqf7d3ogi2xp 9=52p3r7vld33gdc 10=yyftiqax7xkrt3 11=qw5bopej4g56lv 12=464zdma6ypjd6g 13=st3kosjnw4z2fj 14=mdzmihqoul7d2y 15=ia4bjqqrk5r7mj 16=smajvqjdcoe5ak 17=r4neknitv4u3gm 18=cy6kgwakte2qmr)

As most of the parts are used in relation to specific types of footwear only, the terms were added to Appendix A (dashed underline), but like in the first iteration without including them in the physical view (Figure 2) and functional view (Table 2) respectively. The materials used to assemble all different footwear parts together like glue, nails, stitching, however, are essential for any type of shoe. Therefore, these were added to table 1 & 2 and the final presentation in Figure 4 (A3AO overview side) and Figure 5 (A3AO summary side) (for the full size version, see Appendix B: The A3AO of Conventional Footwear).

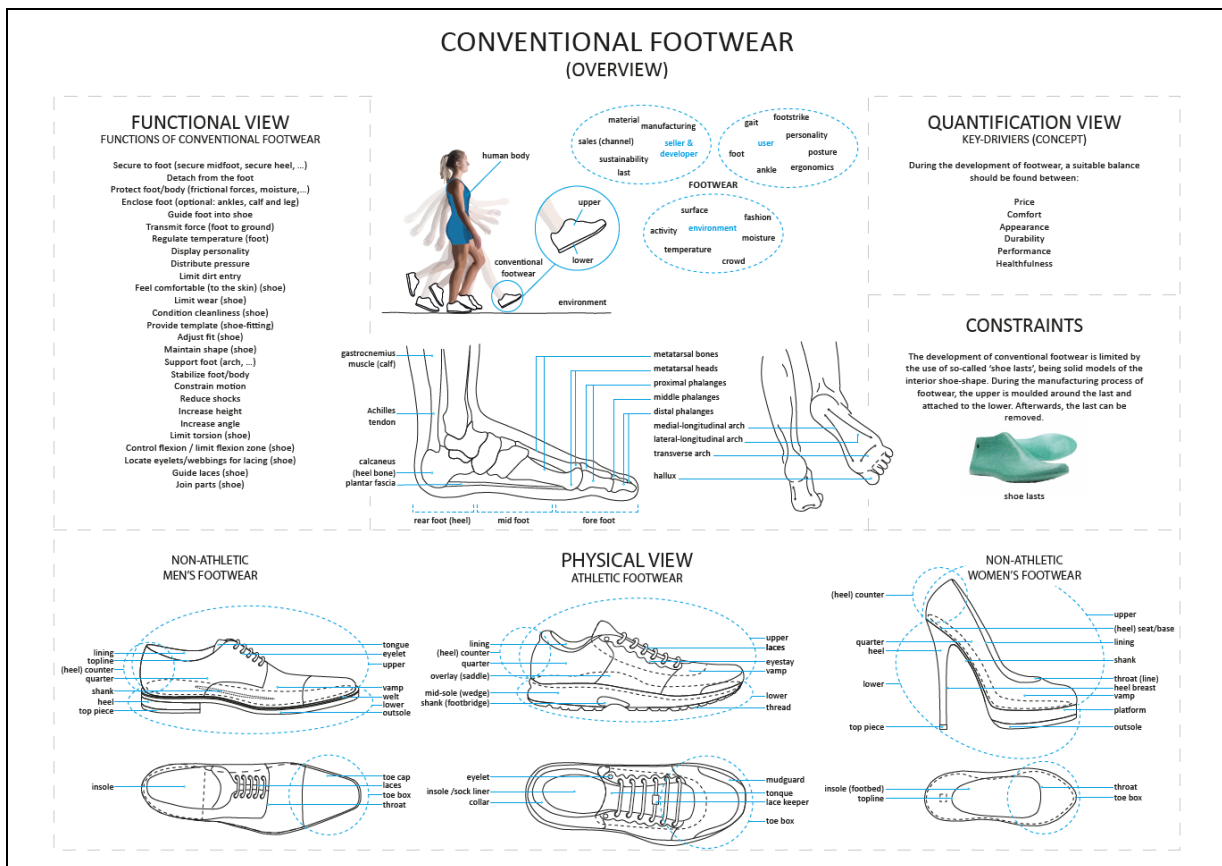


Figure 4: A3AO of Conventional Footwear; Overview

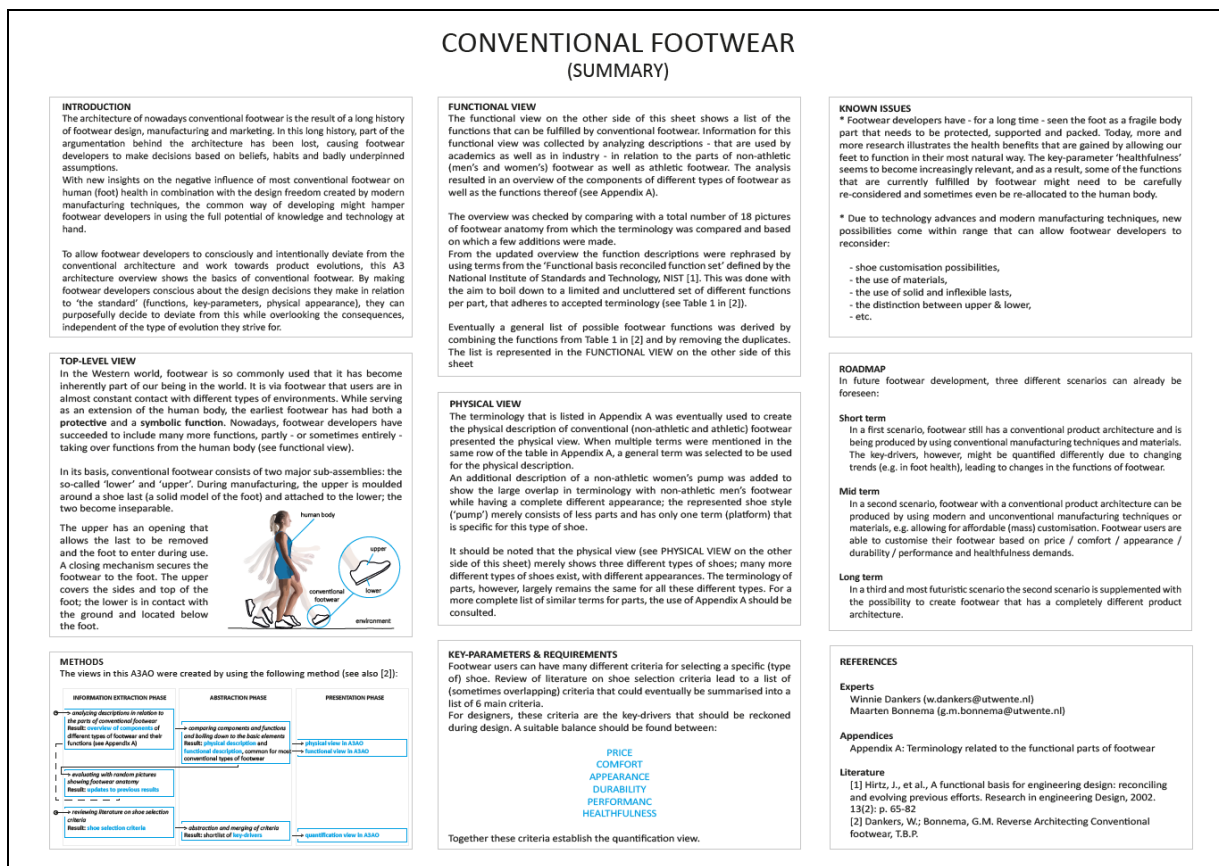


Figure 5: A3AO of Conventional Footwear; Summary

Conclusions

The established A3 Architecture overview shows the result of the decomposition of conventional footwear in relevant architectural aspects. These aspects form a solid basis to enable future footwear development and support the well thought-through development of new architectures. The overviews provide stakeholders of footwear development with means to easily discuss alternative requirements and/or key-parameters, alternative trade-offs, and to enable them to anticipate the impact thereof. In particular the so far undervalued healthiness of footwear can be improved using this architecture description, without compromising existing requirements.

Future work

The A3AO of Conventional Footwear can only prove its success when it is being used by footwear developers and has the desired results. As the A3AO was developed in the context of a bigger project on tools and guidelines for the development of healthy footwear, this will be the first area of application. In relation to this project, it will be complemented with technical knowledge on e.g. materials and production techniques and in-depth understanding of different stakeholder needs (shoe users, producers, shops, etc.). The use, however, is not limited to this project. It is well imaginable that it can also form a good basis for evolutionary developments in e.g. safety shoes. Moreover, the approach that was used in this paper can be applied to develop architecture overviews for other product families as well.

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Biography



Winnie Dankers received her Master's degree in Industrial Design Engineering from the University of Twente (2009) and continued working as an assistant professor at the Laboratory of Design, Production and Management of the faculty of Engineering Technology. She gained teaching experience in IDE in general, scientific & technical writing and visual communication and her research focused on Information Management. After becoming a mother and shortly focusing on lecturing only, she developed an interest in the field of footwear development. She now researches how footwear developers can be supported in developing footwear that better matches the natural functions of the body.



(Gerrit) Maarten Bonnema is an associate professor in systems engineering and multidisciplinary design at the Department of Design, Production and Management of the Faculty of Engineering Technology at the University of Twente. He has worked as a Systems Engineer at ASML. His research aims at supporting system designers, conceptual design and mechatronic design by improving multidisciplinary communication, and systems thinking. An overview of publications can be found at <http://www.tinyurl.com/MaBoPubs>. Two main application areas are high-tech systems and electric mobility. He has a broad teaching expertise spanning design in general, industrial design, and systems engineering.

APPENDIX A:

TERMINOLOGY RELATED TO THE *FUNCTIONAL* PARTS OF FOOTWEAR

Note: The terms that have a dashed underline are added after evaluation of the table.

Terminology	Source			
	Academic & Non-Athletic	Academic & Athletic	Industry & Non-Athletic	Industry & Athletic
lower/ bottom/ sole unit/ sole/soles	- "The components of a shoe can be grouped broadly into those parts that make up the <u>upper</u> and those parts that constitute the <u>lower or bottom</u> ." (McPoil Jr 1988) - "Materials that can be used for shoe uppers can also be used in shoe <u>soles</u> ..." (Luximon & Khandual 2018)	- "One of the most common methods currently used for attaching the <u>upper</u> to the <u>lower</u> is termed "Strobel" lasting." (McPoil 2000) - "There are four basic components of the athletic shoe: <u>outsole</u> , <u>midsole</u> , <u>insole</u> , and the <u>upper</u> ." (Blazer, Jamrog & Schnack 2018)	- "...to bond the <u>upper</u> parts and <u>soles</u> ..." or "in which the <u>upper</u> and <u>sole</u> of the shoe are stitched together" or "The <u>upper</u> part of the shoe, not including the <u>sole</u> " (C&E_Fashions 2019)	<u>Outsole or sole unit</u> : "The bottom component of a shoe that provides grip and traction. The <u>outsole</u> is commonly rubber, but can be high density PU or EVA foam. Dress shoes may have leather <u>bottoms</u> ." (Motawi 2015)
outsole/ outersole / bumper	- "The <u>outsole</u> is the <u>protective</u> layer of material between the plantar surface of the foot and the ground." (McPoil Jr 1988)	- "The <u>outsole</u> is the portion of the shoe that contacts the ground. It <u>provides traction and protects against frictional forces</u> ." (Blazer, Jamrog & Schnack 2018) - "The <u>outsole</u> is the layer of the shoe that comes in contact with the ground." and "The <u>outsole</u> not only helps in <u>maintaining traction</u> but also <u>provides durability, shock absorption, torsional rigidity, and flexibility</u> ." (Khan, Jacobs & Ashbaugh 2013) - "...a thin rubber <u>outersole</u> " (Ramsey et al. 2019)	- " <u>Outsole</u> : The very bottom of the shoe that contacts the ground" (C&E_Fashions 2019) - "This is the <u>outer most sole</u> of the shoe, which is directly exposed to abrasion and wear." And "Ideal soling materials must be <u>waterproof, durable</u> and possess a coefficient of friction high enough to <u>prevent slipping</u> ." (Kippen 2009) - <u>Bumper</u> : The rubber strip attached to the forward facing part of a sneaker sole. The function is to decrease wear to the front of the sole.	<u>Outsole or sole unit</u> : "The bottom component of a shoe that provides grip and traction. The <u>outsole</u> is commonly rubber, but can be high density PU or EVA foam. Dress shoes may have leather <u>bottoms</u> ." (Motawi 2015) - "Since it's the initial point of impact, the <u>outsole</u> often includes features like decoupled heels and <u>footbridges</u> that assist in the overall <u>cushioning and support</u> " (Runner'sWorld 2009)
tread (waffles/ lugs/nubs/ripples)		- "Nubs, ripples, and waffles are commonly placed on the <u>outsides</u> of running shoes. The original reason for this type of outsole design was to <u>improve traction</u> during cross-country running. It has been shown that the waffle or <u>nubbed outsole</u> will contribute to <u>shock attenuation</u> while running on asphalt and concrete." (McPoil Jr 1988)		- "Tread is the part of the outsole that comes in direct contact with the ground. On road-running shoes, <u>treads supply cushioning</u> while giving the shoe a bit of <u>added traction</u> . Runners often refer to these small raised treads as <u>waffles</u> , in reference to the first popular Nike outsole created by Bill Bowerman with the help of his wife's waffle iron. On trail shoes, where <u>traction</u> is more important than <u>cushioning</u> , the raised treads are called <u>lugs</u> ." (Runner'sWorld 2009) - "The <u>outsole lug</u> is a small block of rubber that makes the <u>tread grip</u> " (Motawi 2015)
midsole		- "The <u>midsole</u> of the shoe is an added layer of material located in-between the <u>outsole</u> and <u>insole</u> of a shoe" (Blazer, Jamrog & Schnack 2018) - "Thick cushioned <u>midsoles</u> are commonly added to footwear to provide <u>cushioning and protection</u> from the environment." (Davis 2014) - "The <u>midsole</u> is an important part of the <u>bottom</u> of the shoe. It helps in <u>providing cushioning and stability</u> to the feet. The more cushioned the <u>midsole</u> , the less stability it provides to the feet; therefore, a balance between cushioning and stability to the feet is vital in a shoe" (Khan, Jacobs & Ashbaugh 2013)	- "Midsole: The part of the shoe between the <u>outsole</u> and where the foot rests, usually <u>cushioned</u> ." (C&E_Fashions 2019)	- "Midsole: The component of a shoe between the <u>upper</u> and <u>outsole</u> used to <u>provide cushioning, fit, comfort and support</u> ." (Motawi 2015)
midsole wedge/ wedge/ medial post/ air (or gel) unit	- "In 85mm heel design, some designers will add a <u>wedge</u> or <u>front platform</u> to <u>increase the height</u> . However, the height of the insole should be kept to 85mm. In drawing shoes with a front platform, the heel must be extended and elongated to the same height as the front platform." (Wong & Luximon 2013)	- "... a <u>midsole wedge</u> design is used for all athletic footwear." (McPoil 2000) - "Certain models of nonathletic shoes and almost all athletic footwear use a <u>midsole wedge</u> rather than a <u>shankpiece</u> and <u>heel</u> (Figs. 4, 5). The <u>midsole wedge</u> provides the same functions as the <u>shankpiece</u> and in many types of athletic footwear is the primary component <u>providing shock attenuation</u> . In running shoes, the <u>midsole wedge</u> is flared both laterally and medially to <u>provide increased stability</u> ." (McPoil Jr 1988) - "Wedges are also known as the <u>medial post</u> of a shoe. They lie between the <u>midsole</u> and <u>outsole</u> at the rear of a shoe. They <u>provide shock attenuation and absorption on foot impact</u> and also <u>provide a heel lift</u> . They are designed by tapering the midsole so that the medial side is thicker than the outside, which <u>increases stability and reduces chances of overpronation</u> during running." (Khan, Jacobs & Ashbaugh 2013)		- "Wedge or <u>Midsole wedge</u> : The EVA foam midsole of a shoe, thinner in the front and taller in the heel." (Motawi 2015) - <u>Air (or gel) Unit</u> : An air (or gel) chamber added to the midsole for additional suspension.
insole (board) / footbed/ insock/ sock liner/ sockliner / footbed/ lasting board	- "The <u>insole board</u> is the surface upon which the foot directly rests. The insole board <u>provides a platform</u> upon which the foot can operate and <u>separates the upper</u> from the <u>lower</u> " (McPoil Jr 1988)	- "The insole of a shoe is also known as the <u>sock liner</u> " and "To <u>assess proper shoe fit</u> using the <u>insole</u> , remove it and compare it with the foot as a <u>template</u> ." (Blazer, Jamrog & Schnack 2018) - "Athletic footwear will often have a <u>sockliner</u> , a piece of material placed over the top of the insole board. It may be glued in position or removable." (McPoil Jr 1988)	- "Footbed: The insole of the shoe, where the foot rests. Another term for <u>insole</u> ." (C&E_Fashions 2019) The <u>lining</u> on the insole segment is called <u>'the sock'</u> and may be full-length, three-quarter or just the heel section. Many <u>linings</u> are made of synthetic material and are usually confined to the quarters and the <u>insock</u> ." (Kippen 2009)	- "Footbed or <u>Insole</u> is the foam <u>padded</u> mesh that your foot stands on. May be removable or may be cemented in." And " <u>Insole Board</u> : a paper based board used to <u>provide structure inside a shoe</u> . For example, a stiff hiking boot will have a thick plastic <u>lasting board</u> . Also called <u>sockliner</u> ." (Motawi 2015)
shank/ midfoot shank/ footbridge / support insert	- "The <u>shank</u> of the shoe refers to the center region or 'bridge' between the heel and the metatarsal heads or ball of the foot. The shank should be rigid to <u>prevent the front of the shoe from twisting on the rear portion</u> . To maintain this bridge effect in footwear with a heel, a <u>shankpiece</u> made of stainless steel is placed between the <u>outsole</u> and the <u>insole</u> . The <u>shankpiece</u> does not support the medial longitudinal arch but functions to <u>provide rigidity</u> to the midsection of the shoe and to <u>determine where the shoe will flex during toe-off</u> " (McPoil Jr 1988)	- "...the presence of <u>stability elements</u> such as: heel-counter, thermoplastic <u>midfoot shank</u> ..." (Ramsey et al. 2019)	- Shank: "A metal strip extending from the heel to the ball of the foot to <u>strengthen shoe and add support</u> ." (C&E_Fashions 2019)	- "A reinforced platform under the arch between the <u>heel</u> and the <u>sole</u> that <u>prevents the shoe from bending in the middle</u> . The <u>footbridge</u> , or <u>shank</u> , supports the foot between the heel of the shoe and the forefoot and <u>supplies torsional rigidity</u> to prevent the shoe from twisting easily under landing pressure (excessive twisting can lead to runner's knee and other joint alignment injuries)." (Runner'sWorld 2009) - "Since it's the initial point of impact, the <u>outsole</u> often includes features like decoupled <u>heels</u> and <u>footbridges</u> that assist in the overall <u>cushioning and support</u> " (Runner'sWorld 2009) - <u>Insertor support / support insert</u> : An insert in the midsole for additional support / to constrain motion.
Heel/ rearfoot stabilizer	- "The <u>heel</u> is a component in numerous types of shoes and can be of various lengths depending on the specific <u>style</u> ." And "Men's heels are standardized in shape for most shoe styles and have a heel height of about 1 inch. Women's heels come in numerous shapes and styles to <u>complement different fashions of dress</u> ." (McPoil Jr 1988)		- "Heel - 'Heel' can refer to both the rear, <u>padded area</u> of the underside of the foot, as well as the solid part of a shoe that <u>supports the heel cup</u> ." (C&E_Fashions 2019) - "The heel is the part of the sole that <u>raises the rear of the shoe in relation to the front</u> ." (ShoeGuide 2019) - "When the heel section sits lower than the forefoot the style is called a <u>'negative heel'</u> " (Kippen 2009)	- Rearfoot stabilizer: a support insert in the heel part of the midsole, to stabilize the rearfoot.
top piece			- The ground contact section of the heel is called the <u>top piece</u> . (Kippen 2009) - "The <u>top piece</u> is the actual part of the heel that comes in to <u>contact with the ground</u> " (Muzquiz 2017) - "The part of the heel that comes in contact with the ground is known as the <u>top piece</u> ." (ShoeGuide 2019)	
heel seat/ heel base			Heel seat: "The part of the shoe directly below where the heel of the foot rests, and where the <u>sole</u> and the <u>heel</u> are joined together." (C&E_Fashions 2019) - "The part of the <u>heel</u> next to <u>sole</u> is usually shaped to <u>fit the heel</u> , this is called the <u>heel seat</u> or <u>heel base</u> ." (Kippen 2009) - "The <u>heel seat</u> is the top of the heel that touches the upper, this is typically shaped to <u>match the form of the upper</u> ." (ShoeGuide 2019)	
heel breast			- "The forward-facing side of the heel" (C&E_Fashions 2019) - "The forward facing part of the heel, under the arch of the sole" (ShoeGuide 2019) - "The heel breast describes front face of the heel." (Kippen 2009)	
platform/ front platform/ wedge	- "In 85mm heel design, some designers will add a <u>wedge</u> or <u>front platform</u> to <u>increase the height</u> . However, the height of the <u>insole</u> should be kept to 85mm. In drawing shoes with a <u>front platform</u> , the <u>heel</u> must be extended and elongated to the same height as the <u>front platform</u> ." (Wong & Luximon 2013)			

		Source			
Terminology	Academic & Non-Athletic	Academic & Athletic	Industry & Non-Athletic	Industry & Athletic	
upper/body	<p>- "The components of a shoe can be grouped broadly into those parts that make up the upper and those parts that constitute the lower or bottom." and "The sections of the upper include the vamp, quarter, toe box, throat, insole board, and topline." (McPoil Jr 1988)</p> <p>- "The components include: - Body - Heel - Insole - Sole - Platform." (Pelizzari 2013)</p>	<p>- "The upper of a shoe is the region covering the <i>dorsum (top) of the foot</i>" (Blazer, Jamrog & Schnack 2018)</p> <p>- "The upper is the part of a shoe that covers the <i>top and sides of the foot</i>. The construction uses a highly breathable fabric that can prevent heat buildup, at the same time enhancing durability and providing water resistance, hence making it washable. The typical material used is nylon. Reinforcements are added as leather or synthetic leatherlike materials." (Khan, Jacobs & Ashbaugh 2013)</p>	<p>- "The upper part of the shoe, not including the sole. May be made from leather, fabric or synthetics." (C&E Fashions 2019)</p> <p>- "The entire part of the shoe that covers the <i>foot</i>." (ShoeGuide 2019)</p>	<p>- "In the most basic terms, the upper is the top part of a shoe that encases the foot. It's made from a soft, breathable mesh that gets stretched around a foot form – or last – to mould it into shape. This mesh is reinforced with more durable material and moulded plastic that holds the foot in place" (Runner'sWorld 2009)</p> <p>- "The part of a shoe that encases your foot and essentially holds it in place is called the upper. It covers the entire top part of the shoe." And "The type of material used is generally leather or synthetic leather, which will allow your feet to breathe. These materials will also protect your feet." (BootMoodFoot 2019)</p>	
vamp	<p>- "The vamp is an essential part of the nonathletic and athletic shoe that covers the forefoot and toes. In nonathletic shoes, the vamp can consist of one or several pattern pieces, depending on the toe design intended for the shoe." (McPoil Jr 1988)</p>	<p>- "In athletic footwear, the vamp is usually made from one piece of material to reduce the number of seams that could cause irritation to the dorsum of the toes." (McPoil Jr 1988)</p> <p>- "The vamp is at the forefront of the upper component of the shoe that may consist of several pieces and designs." (Blazer, Jamrog & Schnack 2018)</p>	<p>- "...the vamp is basically the front part of the shoe. Everything from the toe until the quarter in back." (Muzquiz 2017)</p> <p>- "The vamp covers the top (dorsum) of the foot (includes the tongue piece) and superior aspects over the toes." (Kippen 2009)</p> <p>- Vamp: "This part covers the shoe from the top of the toe area to where the laces are. This part of the shoe is highly visible and needs to withstand some wear and tear as its where the shoe flexes. In slip-on shoes, the shoe vamps replace what you would call the tongue in a lace up style." (BootMoodFoot 2019)</p>	<p>- "A part of the upper that surrounds the toebox. If you can pinch a quarter inch, the vamp is too baggy. If you can't wiggle your toes, it's too tight." (Runner'sWorld 2009)</p> <p>- Shoe Vamp: "The vamp is the area on top of the toes. The vamp is often made from breathable mesh or has perforations for venting." (Motawi 2015)</p>	
toe box /toe cap /toe puff/toe counter/cap toe /toe burst panel	<p>- "... the open-toe style exposes the insole in the tip of the toe box." (Wong & Luximon 2013)</p> <p>- "If a shoe is to retain its shape, it is necessary to stiffen it at the toe and heel; this leads to the addition of heel and toe stiffeners, or counters." (Luximon & Khandual 2018)</p>	<p>- "The toe box is the roof covering the toes inside the shoe, which acts to maintain the shape of the anterior shoe and allows adequate room for toes." (Blazer, Jamrog & Schnack 2018)</p> <p>- "The toe box refers to the roofed area over and around the part of the shoe that covers the toes (Fig. 4). The function of the toe box is to retain the shape of the forefoot and allow room for the toes. The height and width of the toe box is dictated by the shape of the last used to construct the shoe. Certain types of nonathletic and athletic footwear offer extra depth in the toe box for individuals with claw toe or hammertoe deformities." (McPoil Jr 1988)</p>	<p>- "Shoes may have a toe cap in the front upper of the shoe. Toe caps can take various forms, but the distinct types are: complete replacements for the front upper of the shoe; stitched over toecaps that add an extra layer to the upper; solid toe caps for protection, such as steel toe caps. Stitch over toe caps may be decorative in nature. Toe caps help add strength to the upper front of the shoe, an area that receives a lot of stress and wear from use." (ShoeGuide 2019)</p> <p>- "Toe box: The toe area of the shoe. Different styles will have different sizes and shapes. Fashion shoes may have tight pointed tips while work boots have extra space for steel toe inserts." (Motawi 2015)</p> <p>- "Cap toe is a leather accent that can be stitched or glued to the toe of the boot. This is sometimes a purely decorative feature, but a cap can markedly reinforce the toe of your boot, which can be a very high-stress area." (Muzquiz 2017)</p>	<p>- Toe burst panel: A part that is used to reduce wear to the upper caused by the toes/nails. The function of the toe burst panel can also be fulfilled by the toe-box/toe cap or mudguard.</p>	
mudguard		<p>- "A running shoe with the vamp constructed from nylon will often have a mudguard, a leather piece that covers only the rim of the toe box" (McPoil Jr 1988)</p>	<p>- "A line of stitching, which is usually thick, running horizontally across the heel." (in dress shoes) (BootMoodFoot 2019)</p>	<p>- "The Mudguard is the shoe pattern part along the forward part of the shoe along the edge of the outsole." (Motawi 2015)</p> <p>- "The Mudguard is the shoe pattern part along the forward part of the shoe along the edge of the outsole. Good protection for limiting wear from abrasive items such as rocks, branches and street. Trail shoes tend to have good guards." (Korcina 2017)</p>	
Throat (throat line)	<p>- "The throat is defined as the line formed by the connection of the rear edge of the vamp and the front part of the quarter." (McPoil Jr 1988)</p>	<p>- "The location of the throat will vary with the design of the shoe. Because the vamp and quarter panels are often one piece in the athletic shoe, the throat is at the eye stay." (McPoil Jr 1988)</p>	<p>- "The front of the vamp next to the toe cap. For shoes were the vamp and quarter panels are one piece the throat is at the eye-stay" (ShoeGuide 2019)</p> <p>- "The central part of the vamp just proximal to the toe box. The throat is formed by the seam joining the vamp to the quarter i.e. throatline. The position of the throat line depends on the construction of the shoe, for example a shorter vamp and longer quarters define a lower throat line. This gives a wider lower opening for the foot to enter the shoe." (Kippen 2009)</p> <p>- "The part of the shoe which covers your instep. An open throat is what's seen in a blucher dress shoe, and a closed throat in balmorals. It's the part of the shoe at the top of the toe cap and front of the vamp." (BootMoodFoot 2019)</p>	<p>- "Because the vamp and quarter panels are often one piece in the athletic shoe, the throat is at the eye stay. This refers to the point where the lacing is attached to the vamp. The throat of the shoe dictates the maximum girth permitted by the shoe." (Kippen 2009)</p>	
tongue /tongue piece/ (lace keeper/ centering straps/ flaps/slits)		<p>- "The tongue is a padded piece that lies immediately beneath the lacing to provide cushioning to the top of the foot." (Khan, Jacobs & Ashbaugh 2013)</p> <p>- "Style lines and unique tongue shapes may be added on the upper bridge part to enhance the style." (Wong & Luximon 2013)</p>	<p>- "The tongue is a flexible piece of material that covers the top of your foot and lies under the laces and quarter of the shoe. The tongue cushions the bony top part of your foot and distributes the pressure from the laces." (Muzquiz 2017)</p> <p>- Tongue: "A strip of leather or other material sewn into the vamp of a laced shoe and extending to the throat of the shoe." (C&E Fashions 2019)</p>	<p>- "The tongue should be pulled up tight and line up straight between the eyestays (which anchor the eyelets). You should use a tongue's lace keeper to hold it in place." (Runner'sWorld 2009)</p> <p>- "The shoe tongue pads the top of the foot. The shoe tongue is connected to the top of the vamp are at the base of the eyestay. The tongue may have elastic centering straps attached to the edge or a tab that can be held by the laces. Depending on the shoe style the tongue may be a single layer of leather or an inch of PU foam." (Motawi 2015)</p> <p>- "It's also, in some sneakers, attached on both sides, so dirt and debris can't get into the sneaker when you are walking or running. You might also find flaps or slits in the top of the tongue, particularly at the midpoint. This allows you to thread laces through it, to secure the sneaker comfortably and prevent it from moving." (BootMoodFoot 2019)</p>	
eye stay/ eye-stay/ eyestay/ eyelet section			<p>- Eye stay: "This refers to the point where the lacing is attached to the vamp." (Kippen 2009)</p> <p>- "... the eyelet section is formed by..." (Kippen 2009)</p>	<p>- Eyestay: "The part around the lace opening (throat of the shoe). Can feature webbings, eyelets, etc." (Motawi 2015)</p>	
laces/ (lacing systems)/ lace-tip (can be replaced by velcro / zippers)		<p>- "To achieve total foot stabilization, a high lacing pattern utilizing at least six eyelets is necessary to accomplish midfoot stabilization in addition to a firm heel counter with a rearfoot stabilizer (McPoil, 1997)." (McPoil 2000)</p>	<p>- "They're the strings used to close the eyelets and hold the shoe on your foot" (BootMoodFoot 2019)</p> <p>- "Lacing systems in sneakers let you customize how the shoe fits you. The arrangement and location, as well as the number of eyelets, allow you to decide how much adjustment you want." (BootMoodFoot 2019)</p>	<p>- "... Sometimes you will be able to lace them right up to the heel collar, especially with high-top style sneakers." (BootMoodFoot 2019)</p> <p>- Lace-tip: The strengthened tip(s) of the laces. The tips allowing for easy pushing/pulling the laces through the eyelets.</p>	
quarter/ quarter panel / (shaft/top)	<p>- "The back half of the nonathletic shoe upper is termed the quarter. In better-grade shoes, the quarter consists of an inside and outside section or panel attached to the vamp in the front and joined together in the rear of the shoe at the back seam. The anterior superior part of the quarter contains the eyelets for the laces." (McPoil Jr 1988)</p>	<p>- "In an athletic shoe, the vamp and quarter panels are often one continuous piece of nylon or leather with additional leather pieces added to reinforce critical areas of the shoe." (McPoil Jr 1988)</p>	<p>- "The rear and sides of the upper that covers the heel that are behind the vamp. The heel section of the quarter is often strengthened with a stiffener, which helps support the rear of the foot. Some shoe designs use a continuous piece of leather for the vamp and quarter." (ShoeGuide 2019)</p> <p>- "In boots the quarter is referred to as top" (Kippen 2009)</p> <p>- "This term refers to the sides of the shoe which cover the area from the vamp to the heel. The quarter is usually reinforced with a stiffener at the heel area, to support the back of your foot" (BootMoodFoot 2019)</p> <p>- "The shaft of the boot which is the part of a boot that covers your ankles, calf, and leg. They can vary in length and be secured with laces, zips, or just pull on." (BootMoodFoot 2019)</p> <p>- "In boots the quarter is referred to as top" (Kippen 2009)</p>	<p>- "The shoe part Quarter Panel: The Quarter Panel is the main shoe pattern part on the side of the shoe pattern. The Nike Swoosh, New Balance N and the Vans V-Bar are all located on the quarter panel" (Motawi 2015)</p>	
overlay /saddle /arch bandage / foxing		<p>- "Reinforcement added to the region of the medial longitudinal arch is termed the saddle if it is added to the outside of the shoe or the arch bandage if it is added to the inside of the shoe" (McPoil Jr 1988)</p>	<p>- Foxing: The term foxing is used for almost any additional piece of leather/fabric attached to the outside of the vamp/quarter to add additional strength or to reduce wear, similar to an overlay.</p>	<p>- Overlay: "These strips work with the laces and eyestays to make the shoe conform to the shape of the foot." (Runner'sWorld 2009)</p> <p>- Overlay: "Pretty much anything that is stitched or bonded to the upper, though the term most commonly refers to the reinforcing strips that provide structure to the shoe." (Runner'sWorld 2009)</p> <p>- Overlay: "An upper part which is over another part. The Nike Swoosh logo is what I would call and Overlay part." (Motawi 2015)</p> <p>- "Saddle: A reinforced mesh that tightly wraps the midfoot and supports the arch. If it's not snug, the foot will move inside the shoe, causing blisters." (Runner'sWorld 2009)</p>	
(heel) stiffener/ (heel) counter/ backstay/ foxing / mustache	<p>- "If a shoe is to retain its shape, it is necessary to stiffen it at the toe and heel; this leads to the addition of heel and toe stiffeners, or counters." (Luximon & Khandual 2018)</p> <p>- "The counter is a component of the quarter that stabilizes the hindfoot in the shoe and retains the shape of the posterior portion of the shoe." (McPoil Jr 1988)</p> <p>- "The foxing is an additional piece of leather that covers the counter externally." (McPoil Jr 1988)</p>	<p>- "The heel counter is the stiff posterior backing of the shoe that stabilizes heel motion, which helps support the shape of the posterior aspect with increasing wear, while keeping the foot striding in a forward direction." (Blazer, Jamrog & Schnack 2018)</p>	<p>- "Heel: This is the part at the back of the shoe which is usually stiffened. It may have a seam up the center of it, where the upper is stitched." And "Heel counter: The name given to the material used to reinforce and stiffen the heel. It can't be seen by the eye as it's enclosed between the outer and inner linings of the shoe." (BootMoodFoot 2019)</p> <p>- "A stiff piece of material at the heel of a shoe positioned between the lining and upper that helps maintain the shape of the shoe. The counter helps strengthen the rear of the shoe." (ShoeGuide 2019)</p> <p>- "The counter or backstay is a strip of leather that runs up the back of a shoe or boot. This piece of leather used for additional stability and sometimes to connect the two halves of the quarter." (Muzquiz 2017)</p> <p>- Backstay: This is another part that can't be seen, and it helps reinforce the counter running down the back of the heel." (BootMoodFoot 2019)</p>	<p>- "In some children's shoes and athletic footwear the stiffener is extended on the medial of the arch to provide an anti-pronatory wedge." (Kippen 2009)</p> <p>- "Internal or external, the heel counter is the pattern part that covers the heel of the shoe. The internal heel counter can be made of rubber (for vulcanized shoes), thermo plastic (for cold cement shoes), chemi sheet (for really cheap shoes), or leather for dress shoes. Depending on the shoe type the counter can be thin and soft or stiff and sturdy." (Motawi 2015)</p> <p>- Mustache: A part with a mustache shaped pattern, added on the outside of the quarter, at the back, above the counter. The function of the mustache is similar to that of the counter, and is used in classic sneakers.</p>	

Terminology	Source			
	Academic & Non-Athletic	Academic & Athletic	Industry & Non-Athletic	Industry & Athletic
topline /collar /heel collar /heel cuff/ Achilles tendon protector / back tab / heel notch / back-strap	-“The topline refers to the top rim of the quarter in a nonathletic shoe.” And “When the foot is placed in the shoe, the topline should fit snugly against the heel.”(McPoil Jr 1988)	“In athletic footwear, the topline is usually padded and is termed the collar.”(McPoil Jr 1988) -“The collar covers the ankle and has a projection that comes up above the heel to help protect the Achilles tendon from friction and irritation”(Khan, Jacobs & Ashbaugh 2013)	-“Topline: The top edge of the upper”(ShoeGuide 2019) “The top edge of the sides and back of the quarter describes the topline.”(Kippen 2009) -“Made out of a soft material, the collar should wrap just below the ankle and supply a snug, gap-free fit.”(Runner’sWorld 2009)	-“Heel collar: This is the name given to the cushioned area around the top of the heel opening on a sneaker. Also known as the heel cuff, it is generally padded for added comfort and thicker than the rest of the upper. There is often a loop attached to it as well, which helps you pull your sneaker onto your foot”(BootMoodFoot 2019) -“heel notch: A relief cut that allows the runner to flex and bends without the shoe rubbing on the Achilles tendon. Also called Achilles tendon protector or Achilles tendon notch.”(Kircina 2017) - Back-strap/rear-strap: The loop that is attached to the back of the quarter, sometimes as an extension of the back-stay. It can be used for easy shoe-access and prevents the back of the quarter from being suppressed.
eyelets /hooked eyelets/ speed hooks/ webbings/ (grommet)	-“To provide stability, footwear should have a firm counter, a shankpiece or wedge, and four to six pairs of eyelets” and “The anterior superior part of the quarter contains the eyelets for the laces.”(McPoil Jr 1988)	-“To achieve total foot stabilization, a high lacing pattern utilizing at least six eyelets is necessary to accomplish midfoot stabilization in addition to a firm heel counter with a rearfoot stabilizer (McPoil, 1997).”(McPoil 2000)	-“Eyelets are the holes that are punched in the upper to allow the foot to be laced up. Eyelets are usually reinforced with a metal grommet to protect the structural integrity of the upper and to avoid fraying.”(Muzquiz 2017) -eyelets: “These are the holes for the laces to be threaded through.”(BootMoodFoot 2019) -“Speed hooks are little metal doo-hickeys that make tying your shoes so much easier. Instead of having to lace up your boot all the way to the top, you can hitch your laces over these hooks. These are also referred to as hooked eyelets.”(Muzquiz 2017) -“In Oxford style lacing shoes, the eyelet section is formed by the superior part of the quarter (while the underlying tongue is part of the vamp). In the Gibson style the lacing segment forms part of the vamp”(Kippen 2009)	-“A hole through which you lace up a shoe”(Motawi 2015) -“can feature webbings, eyelets, etc.”(Motawi 2015)
Lining(s)/ the sock	“Hydrophilic leather that is ideal for soles, linings and insoles, is less malleable, harder and more difficult to work with than either synthetic- or chrome-tanned leathers.”(Luximon & Khandual 2018)		-“Most shoes include a lining on the inside of the shoe, around the vamp and quarter. These linings improve comfort, and can help increase the lifespan of the shoe.”(ShoeGuide 2019) “In quality shoes the quarters and vamps are lined to enhance comfort and durability. Linings may consist of various materials i.e. leathers, fabrics, and manmade synthetics. The lining on the insole segment is called ‘the sock’ and may be full-length, three-quarter or just the heel section. Many linings are made of synthetic material and are usually confined to the quarters and the insock.”(Kippen 2009)	-“Linings of a shoe 1. Quarter Lining: horseshoe shape around back part of shoe 2. Vamp Lining: inside upper of forepart and toe of shoe 3. Sock Lining: covering all OR part of the top surface of the insole.”(Motawi 2015)
welt/ feather			-Welt: “A strip of material that joins the upper to the sole.”(ShoeGuide 2019) -“The welt is a strip of leather around the edge of the sole and to which the upper is attached. There are a number of different styles of welts, the most complicated of which are becoming more and more expensive to make. But a high quality welt can make all the difference in the world. A Goodyear welt for example should make your shoe or boot water resistant and allow for the outsole to be replaced should it wear out.”(Muzquiz 2017) “The strip of material which joins the upper to the sole. Most shoes will be bonded by Goodyear-welted construction. Some shoes use an imitation welt stitched around the top flat edge of the sole for decorative purposes, but it is not a functional part of the shoe.”(Kippen 2009) “the welt is attached to the feather of the insole.” and “The feather is the curve around the edge of the insole where the upper is attached” (Muzquiz 2017) -Feather: “A thin strip of leather between the upper and the sole, around the whole of the outside of the shoe. It joins the two together.”(BootMoodFoot 2019) -“The part of the shoe where the upper’s edge meets the sole”(ShoeGuide 2019)	
Assembly Stitching/ glue / nails			Stitching / glue / nails: The materials used to assemble all different parts together.	

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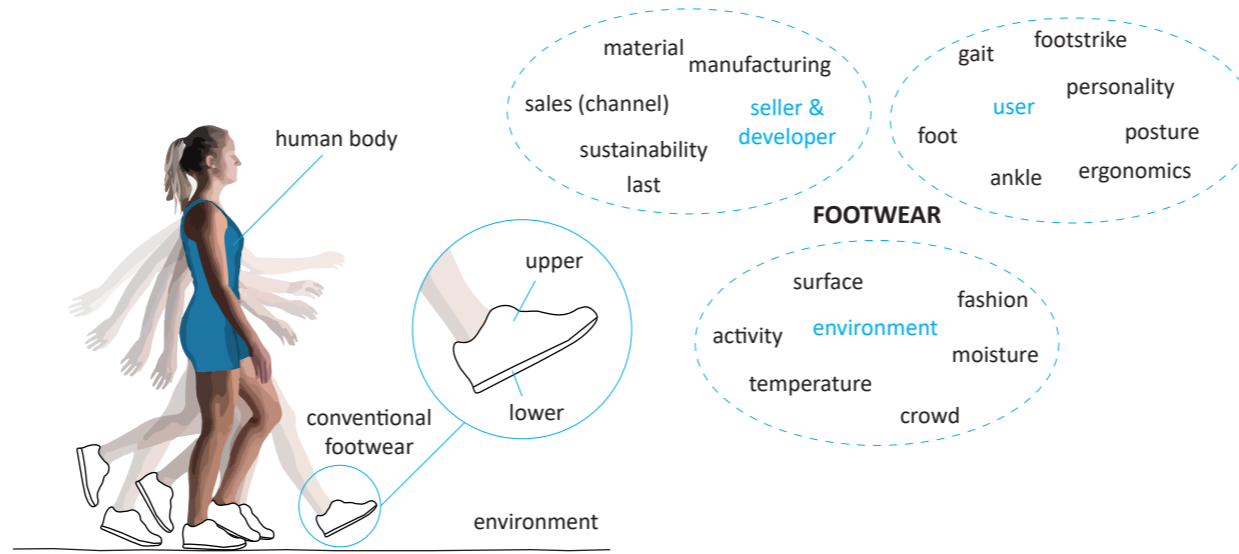
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APPENDIX B:
THE A3AO OF CONVENTIONAL FOOTWEAR

CONVENTIONAL FOOTWEAR (OVERVIEW)

FUNCTIONAL VIEW FUNCTIONS OF CONVENTIONAL FOOTWEAR

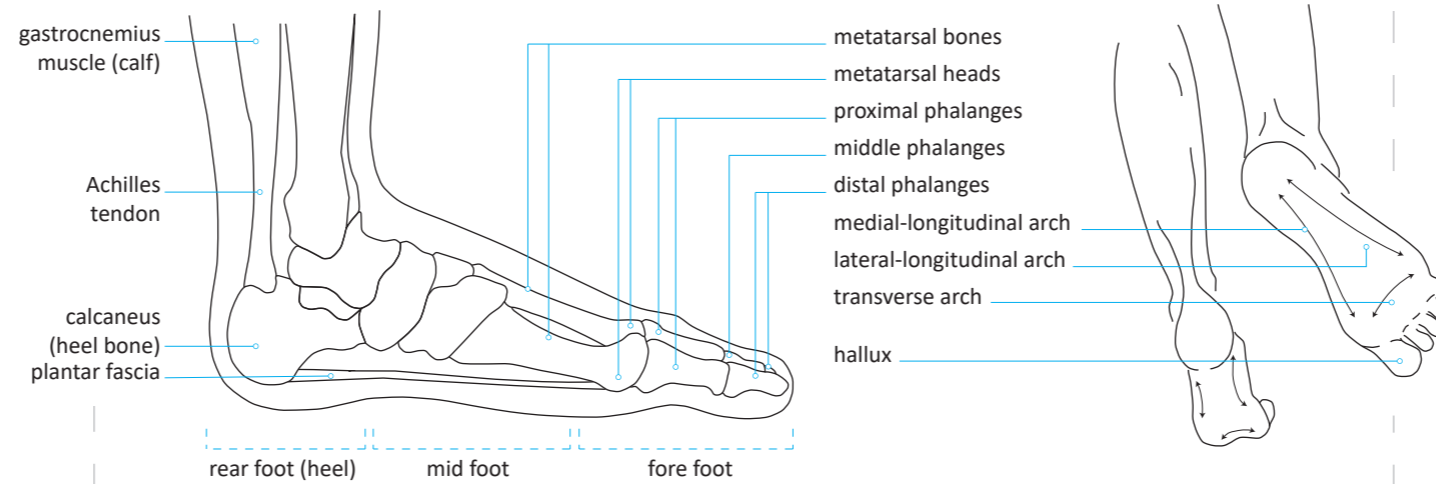
- Secure to foot (secure midfoot, secure heel, ...)
- Detach from the foot
- Protect foot/body (frictional forces, moisture,...)
- Enclose foot (optional: ankles, calf and leg)
- Guide foot into shoe
- Transmit force (foot to ground)
- Regulate temperature (foot)
- Display personality
- Distribute pressure
- Limit dirt entry
- Feel comfortable (to the skin) (shoe)
- Limit wear (shoe)
- Condition cleanliness (shoe)
- Provide template (shoe-fitting)
- Adjust fit (shoe)
- Maintain shape (shoe)
- Support foot (arch, ...)
- Stabilize foot/body
- Constrain motion
- Reduce shocks
- Increase height
- Increase angle
- Limit torsion (shoe)
- Control flexion / limit flexion zone (shoe)
- Locate eyelets/webbings for lacing (shoe)
- Guide laces (shoe)
- Join parts (shoe)



QUANTIFICATION VIEW KEY-DRIVERS (CONCEPT)

During the development of footwear, a suitable balance should be found between:

- Price
- Comfort
- Appearance
- Durability
- Performance
- Healthfulness



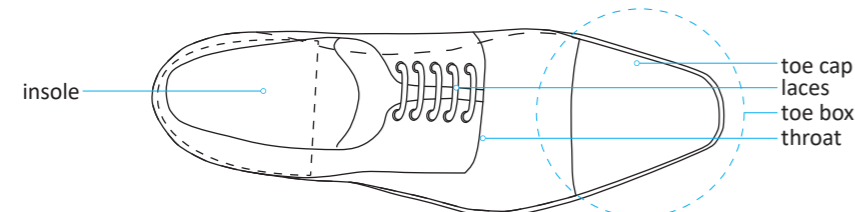
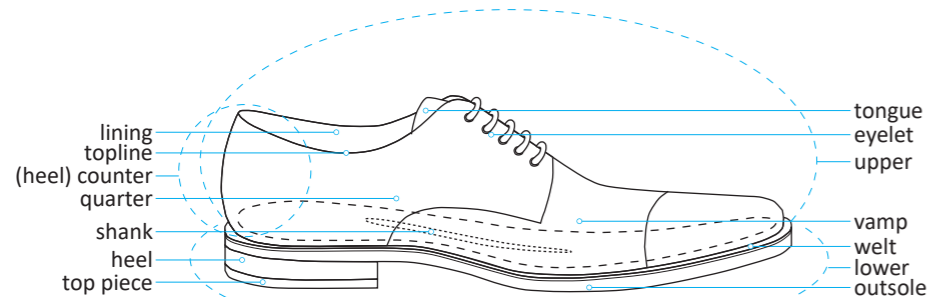
CONSTRAINTS

The development of conventional footwear is limited by the use of so-called 'shoe lasts', being solid models of the interior shoe-shape. During the manufacturing process of footwear, the upper is moulded around the last and attached to the lower. Afterwards, the last can be removed.

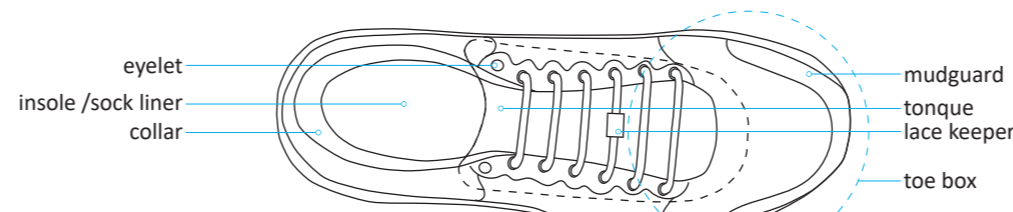
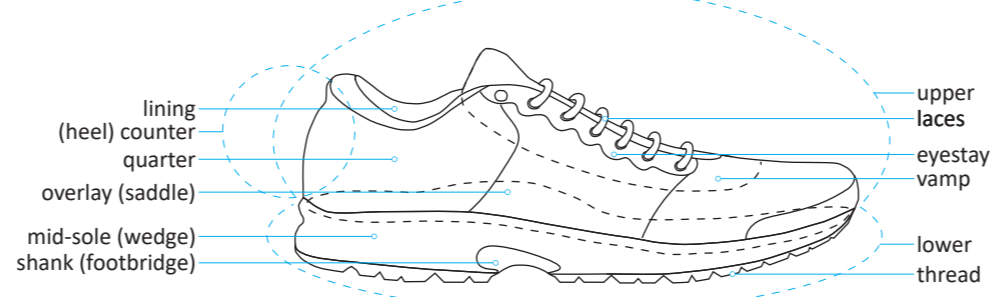


shoe lasts

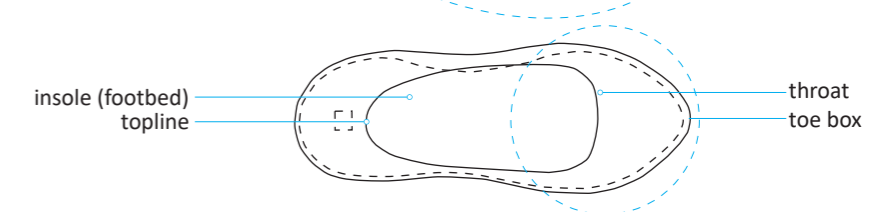
NON-ATHLETIC MEN'S FOOTWEAR



PHYSICAL VIEW ATHLETIC FOOTWEAR



NON-ATHLETIC WOMEN'S FOOTWEAR



CONVENTIONAL FOOTWEAR (SUMMARY)

INTRODUCTION

The architecture of nowadays conventional footwear is the result of a long history of footwear design, manufacturing and marketing. In this long history, part of the argumentation behind the architecture has been lost, causing footwear developers to make decisions based on beliefs, habits and badly underpinned assumptions.

With new insights on the negative influence of most conventional footwear on human (foot) health in combination with the design freedom created by modern manufacturing techniques, the common way of developing might hamper footwear developers in using the full potential of knowledge and technology at hand.

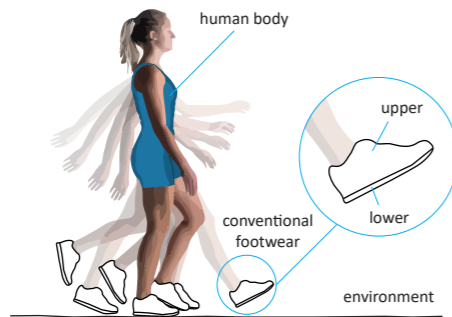
To allow footwear developers to consciously and intentionally deviate from the conventional architecture and work towards product evolutions, this A3 architecture overview shows the basics of conventional footwear. By making footwear developers conscious about the design decisions they make in relation to 'the standard' (functions, key-parameters, physical appearance), they can purposefully decide to deviate from this while overlooking the consequences, independent of the type of evolution they strive for.

TOP-LEVEL VIEW

In the Western world, footwear is so commonly used that it has become inherently part of our being in the world. It is via footwear that users are in almost constant contact with different types of environments. While serving as an extension of the human body, the earliest footwear has had both a **protective** and a **symbolic function**. Nowadays, footwear developers have succeeded to include many more functions, partly - or sometimes entirely - taking over functions from the human body (see functional view).

In its basis, conventional footwear consists of two major sub-assemblies: the so-called 'lower' and 'upper'. During manufacturing, the upper is moulded around a shoe last (a solid model of the foot) and attached to the lower; the two become inseparable.

The upper has an opening that allows the last to be removed and the foot to enter during use. A closing mechanism secures the footwear to the foot. The upper covers the sides and top of the foot; the lower is in contact with the ground and located below the foot.



FUNCTIONAL VIEW

The functional view on the other side of this sheet shows a list of the functions that can be fulfilled by conventional footwear. Information for this functional view was collected by analyzing descriptions - that are used by academics as well as in industry - in relation to the parts of non-athletic (men's and women's) footwear as well as athletic footwear. The analysis resulted in an overview of the components of different types of footwear as well as the functions thereof (see Appendix A).

The overview was checked by comparing with a total number of 18 pictures of footwear anatomy from which the terminology was compared and based on which a few additions were made.

From the updated overview the function descriptions were rephrased by using terms from the 'Functional basis reconciled function set' defined by the National Institute of Standards and Technology, NIST [1]. This was done with the aim to boil down to a limited and uncluttered set of different functions per part, that adheres to accepted terminology (see Table 1 in [2]).

Eventually a general list of possible footwear functions was derived by combining the functions from Table 1 in [2] and by removing the duplicates. The list is represented in the FUNCTIONAL VIEW on the other side of this sheet

PHYSICAL VIEW

The terminology that is listed in Appendix A was eventually used to create the physical description of conventional (non-athletic and athletic) footwear presented the physical view. When multiple terms were mentioned in the same row of the table in Appendix A, a general term was selected to be used for the physical description.

An additional description of a non-athletic women's pump was added to show the large overlap in terminology with non-athletic men's footwear while having a complete different appearance; the represented shoe style ('pump') merely consists of less parts and has only one term (platform) that is specific for this type of shoe.

It should be noted that the physical view (see PHYSICAL VIEW on the other side of this sheet) merely shows three different types of shoes; many more different types of shoes exist, with different appearances. The terminology of parts, however, largely remains the same for all these different types. For a more complete list of similar terms for parts, the use of Appendix A should be consulted.

KEY-PARAMETERS & REQUIREMENTS

Footwear users can have many different criteria for selecting a specific (type of) shoe. Review of literature on shoe selection criteria lead to a list of (sometimes overlapping) criteria that could eventually be summarised into a list of 6 main criteria.

For designers, these criteria are the key-drivers that should be reckoned during design. A suitable balance should be found between:

PRICE
COMFORT
APPEARANCE
DURABILITY
PERFORMANC
HEALTHFULNESS

Together these criteria establish the quantification view.

KNOWN ISSUES

* Footwear developers have - for a long time - seen the foot as a fragile body part that needs to be protected, supported and packed. Today, more and more research illustrates the health benefits that are gained by allowing our feet to function in their most natural way. The key-parameter 'healthfulness' seems to become increasingly relevant, and as a result, some of the functions that are currently fulfilled by footwear might need to be carefully re-considered and sometimes even be re-allocated to the human body.

* Due to technology advances and modern manufacturing techniques, new possibilities come within range that can allow footwear developers to reconsider:

- shoe customisation possibilities,
- the use of materials,
- the use of solid and inflexible lasts,
- the distinction between upper & lower,
- etc.

ROADMAP

In future footwear development, three different scenarios can already be foreseen:

Short term

In a first scenario, footwear still has a conventional product architecture and is being produced by using conventional manufacturing techniques and materials. The key-drivers, however, might be quantified differently due to changing trends (e.g. in foot health), leading to changes in the functions of footwear.

Mid term

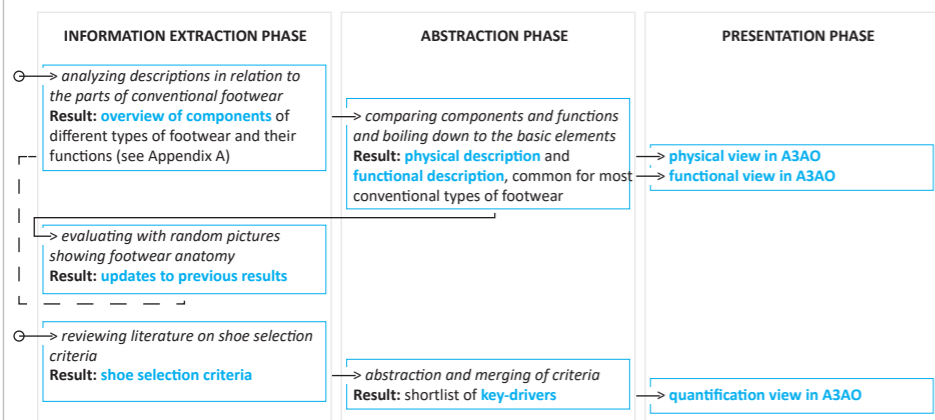
In a second scenario, footwear with a conventional product architecture can be produced by using modern and unconventional manufacturing techniques or materials, e.g. allowing for affordable (mass) customisation. Footwear users are able to customise their footwear based on price / comfort / appearance / durability / performance and healthfulness demands.

Long term

In a third and most futuristic scenario the second scenario is supplemented with the possibility to create footwear that has a completely different product architecture.

METHODS

The views in this A3AO were created by using the following method (see also [2]):



REFERENCES

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Appendices

Appendix A: Terminology related to the functional parts of footwear

Literature

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