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The Digital Disruption of Virtual Reality and the Future of the Steel Roller Coaster: An Initial Industry Analysis

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Abstract

In the overlapping realms of digital design, engineering, tourism/leisure and thrill seeking, roller coasters are sought after attractions capable of drawing millions of visitors to amusement and theme parks located all over the world. More recently (from 2015) however, numerous new and existing roller coasters have been retrofitted to accommodate a Virtual Reality (VR) experience overlay – evidence of the infiltration of the digital disruption in yet another industry. Subsequently, in this paper, we firstly endeavour to examine the global footprint of the European Steel Roller Coaster Industry (ESRCI) as an export of the European economic region, while secondly, determining to what extent Virtual Reality (VR) has already infiltrated the industry. As a result, an exploratory study was conducted to identify the operational roller coasters of 23 European-based steel roller coaster manufacturers, also noting the country in which each roller coaster is operating. The results were used to establish a global footprint of the ESRCI, while an indication is also given to whether any of these manufacturers' operational roller coasters have already been retrofitted with VR. Initial findings confirm that although the concept of the VR enhanced roller coaster is still fairly new (introduced in 2015), the effects are already wide spread with 8 of the 23 ESRC manufacturers having been affected by VR additions to one or more of their operational roller coasters within the 3 year time frame (2015 – 2017). While VR product development and integration strategies are still in the early stages, as it currently stands, VR is identified as a key role player and complementary technology for further consideration in the roller coaster industry going forward. Moreover, by adopting a manufacturer and industry centric point of view on the subject matter, this paper provides a point of departure for examining the current usage and trends of VR in the ESRCI, which may be transferrable to the roller coaster and amusement industries at large. This, in turn, may advance future discourse in the understanding of whether VR poses a threat to new roller coaster infrastructure development, is a complimentary asset to existing roller coaster infrastructure or is merely a passing fad.

Keywords: Digital Disruption, Virtual Reality, Roller Coaster, Europe, Amusement Park, Theme Park

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Introduction

The expression 'the whole is more than the sum of its parts' can be used to describe numerous occurrences of a mathematical, psychological and interpersonal nature. While the particular context of its use leaves room for individual interpretation, Upton et al. (2014) note that this principle describes the synergy which exists between individuals working together in a

cooperative effort; collectively, they are able to achieve an outcome superior to that of only 1 or 2 people working alone.

The same reasoning may be applied to amusement and theme parks (henceforth collectively referred to as 'parks') where the high density of thrills in close proximity to one another may deliver a more intense or heightened experience for visitors than 1 or 2 thrills would be able to do in isolation. As a result, in symbiosis with the automobile and car culture, these parks have subsequently displaced many older forms of amusement centres such as the carnival, fair, hippodrome, midway and circus, while having sparked new trends in tourism, travel, recreation, family life and leisure economics (King, 1981).

With leisure experiences such as amusement and theme parks attracting both domestic and international tourists, and tourists being a highly sought-after commodity capable of turning almost any tourism destination and its attractions into thriving exports (Louw, 2017), the optimal management of these parks becomes a particular topic of interest from not only a touristic perspective, but also managerial and economic perspectives.

In 2011 for example, nearly 30,000 attractions in the United States (US) generated a total nationwide economic impact of almost $219 billion, including $91 billion in direct impacts (which include attractions' sales, annual capital expenditures and ancillary spending by attractions' patrons) and $127 billion in indirect and induced impacts (Oxford Economics, 2013). A total of 2.3 million jobs (including seasonal employment as well as part-time and full-time jobs) were supported by the industry. Furthermore, the US attractions industry grew at nearly twice the rate of the overall US economy and over a timeframe of seven years (2004 – 2011), the impact of attractions grew 50%, with an average growth rate of 6% per annum (Oxford Economics, 2013).

When looking at the economic impacts of the US attractions industry by subsector, table 1 points out that amusement/theme parks made the biggest contribution overall when compared to museums, family entertainment centres (FECs), zoos, botanical gardens and aquariums, water parks, historical sites, as well as nature parks.

	Economic Output ($ Billions)		Labour Income ($ Billions)		Jobs	
Industry	Direct Economic Impact	Total Economic Impact	Direct Labour Income	Total Labour Income	Direct Jobs	Total Jobs
Amusement/Theme Parks	$50.9	$122.0	$15.6	$39.8	695,241	1,261,467
Museums	$15.4	$36.8	$4.3	$10.3	163,291	341,456
Family Entertainment Centres (FECs)	$13.3	$31.6	$3.4	$7.9	257,966	397,411
Zoos, Botanical Gardens, Aquariums	$4.7	$11.3	$1.5	$3.7	57,207	119,624
Water Parks	$4.5	$10.8	$1.3	$3.3	68,527	124,337
Historical Sites	$1.5	$3.5	$0.4	$1.1	20,630	43,139
Nature Parks	$1.1	$2.7	$0.3	$0.8	12,190	25,491
Total, Attractions Industry	**$91.4**	**$218.7**	**$26.8**	**$66.9**	**1,275,051**	**2,312,925**

Table 1
Summary Economic Impacts of the US Attractions Industry by Subsector, 2011 ($ Billions & Total Jobs) (Euromonitor Consulting, 2017)

Typically, everyone in a family finds something to do at an amusement park as it is a large, high-profile attraction that offers guests a complex of rides, food services, and games (Euromonitor Consulting, 2017). Theme parks are very similar to amusement parks, however, an overreaching theme ties all elements of the park together.

King (1981) noted that as the US in particular becomes more and more a world of leisure, amusement and theme parks take on an increasingly prominent role as the keen cutting edge

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of the leisure experience and its interpretation. The focus, however, is not only on attracting new visitors with existing attractions, but also attracting return visitors with new or revitalised attractions.

When looking specifically at new attractions in figure 1, a benchmark study conducted in 2016 indicated the most desired new attraction for the majority of 135 amusement and theme parks from across the globe, to be a steel roller coaster (Euromonitor Consulting, 2017).

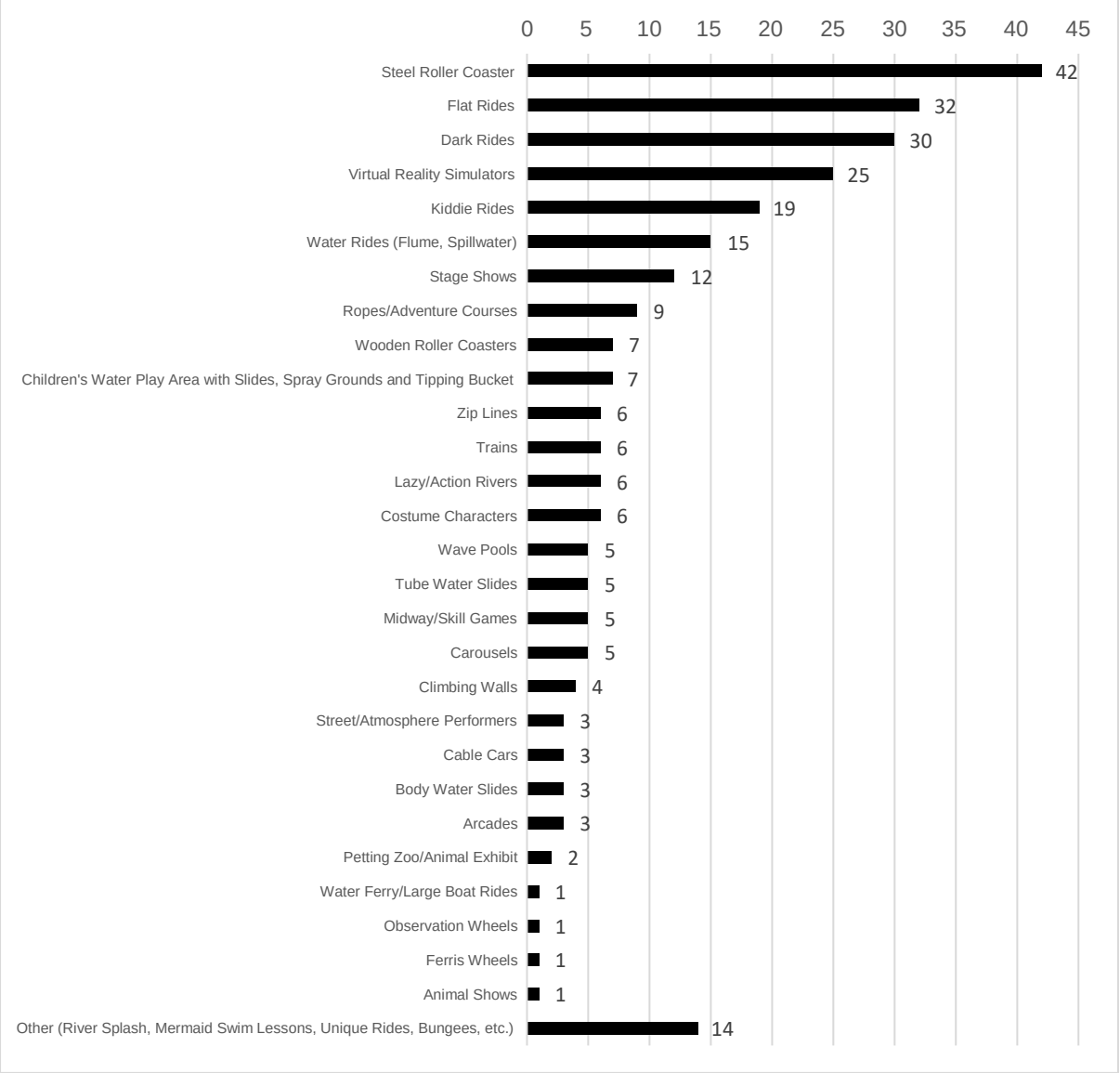

Fig. 1
Desired new attraction in next 2-3 years (N=135) as recorded in 2016 (Euromonitor Consulting, 2017)

Despite flat rides, dark rides, Virtual Reality (VR) simulators and kiddie rides also falling under the top 5 of the most desired new attractions for park owners in 2016, Anderson (1999) points out that, “in both its history and its contemporary incarnations, no artefact more completely represents the culture of American amusement than the roller coaster”. Furthermore, Neil (1981) noted that whether or not a particular roller coaster is, in fact, a primary attraction or

even just visually impressive, its presence immediately communicates in a way that no other single image can.

One may therefore argue that roller coasters play an important role in not only establishing the visual and visceral attractiveness that attract tourists to a particular amusement or theme park (Mars et al., 2017) but, in the case of the US specifically, also contribute to the success of the amusement industry as a global tourism export. Despite this tremendous export potential, however, it is worth noting that many individual components (rides/attractions/thrills) of these parks may, in fact, be imported from other countries – an export of these countries in their own right. This also holds true for the most desired new attraction of 2016, the steel roller coaster. The European Steel Roller Coaster Industry (ESRCI) becomes of particular interest in this case, as it is an industry that has managed to establish itself not only within the US, but also global amusement market.

As a result, in this paper, we commence by launching an investigation into the role that the roller coaster plays in the amusement and theme park industry, followed by a look at the impact that the ESRCI in particular, has had (up until 2017) on the global amusement industry. By analysing the active steel roller coaster instalments of 23 ESRC manufacturers, we proceed to identify the industry's existing global footprint and identify the trends of the ESRC as a global export of the continent also highlighting the historically most popular and predicted future importer of the product.

As with any infrastructure development, however, roller coaster infrastructure eventually also becomes outdated which not only has numerous implications from a maintenance perspective (i.e. maintenance costs increasing over time, having difficulty finding and replacing older components, replacing discontinued products etc.), but the space consuming infrastructure (track) that supports these rides, also remains static. This implies that there is not much of a new experience on offer for visitors who have already mustered the courage to conquer these rides which may prove to be cumbersome for park management as far as visitor attendance is concerned and, especially, as far as attracting return visitors is concerned.

With the introduction of VR, however, amusement and theme parks are offered an opportunity to revitalise older roller coasters by means of a new, digital experience overlay.

As such, we investigate to what extent the roller coasters of manufacturers that form part of the ESRCI have already (up to 2017) been affected by VR in an attempt to gauge the proliferation of the technology.

The Role of the Roller Coaster in Amusement and Theme Parks

The amusement and theme park sector has been found to be different from traditional tourism outlets because it exists in a human-created, artificial environment, yet it is an increasingly competitive and attractive sector (Lillestol et al., 2015; Henderson, 2010). Amusement and theme park entrepreneurs who ignore the roller coaster and its power however, run the grave risk of losing a vital symbol – arguably the best symbol of relaxation, fun and adventure, in addition to being a beacon of navigation for visitors while exploring a park (Neil, 1981). Further studies by Burt (2016) indicate that roller coasters have a far more complex impact on society as an important outlet for access to primal sensations, an economic drawcard for multibillion-dollar leisure industries, and a source of powerful memories of fun and childhood. Additionally they serve as a centrepiece to a dedicated community of roller coaster enthusiasts, offer riders a way to automatically focus their attention while also allowing riders to safely experience

extreme forces and unusual sensations that cannot be encountered safely elsewhere in everyday life (Burt, 2016).

With numerous different kinds of roller coasters in existence, annual events such as the Golden Ticket Awards are used to recognise not only the best parks, rides and manufacturers, but also to showcase industry achievement and ride diversity.

When looking at the Golden Ticket awards for the top steel roller coaster over the past 5 years (2013–2017) as summarised in table 2, it is interesting to note that not only has the honour of first position been bestowed upon a European manufacturer every year during this timeframe, but also the second and third place awards.

Rank	Roller Coaster Name	Park	Location	Opening Year	Points	Manufacturer/ Supplier	Origin
2017							
1	Fury 325	Carowinds	Charlotte, N.C., USA	2015	1354	B&M	Europe (CH)
2	Millennium Force	Cedar Point	Sandusky, Ohio, USA	2000	1129	Intamin	Europe (LI)
3	Superman The Ride	Six Flags New England	Agawam, Mass., USA	2000	705	Intamin	Europe (LI)
4	Iron Rattler	Six Flags Fiesta Texas	San Antonio, Texas, USA	2013	657	RMC	USA
5	Expedition GeForce	Holiday Park	Hassloch, Germany	2001	575	Intamin	Europe (LI)
2016							
1	Fury 325	Carowinds	Charlotte, N.C., USA	2015	1126	B&M	Europe (CH)
2	Millennium Force	Cedar Point	Sandusky, Ohio, USA	2000	1122	Intamin	Europe (LI)
3	Superman The Ride	Six Flags New England	Agawam, Mass., USA	2000	698	Intamin	Europe (LI)
4	Expedition GeForce	Holiday Park	Hassloch, Germany	2001	613	Intamin	Europe (LI)
5	Nitro	Six Flags Great Adventure	Jackson, N.J., USA	2001	454	B&M	Europe (CH)
2015							
1	Millennium Force	Cedar Point	Sandusky, Ohio, USA	2000	1205	Intamin	Europe (LI)
2	Bizarro	Six Flags New England	Agawam, Mass., USA	2000	929	Intamin	Europe (LI)
3	Expedition GeForce	Holiday Park	Hassloch, Germany	2001	714	Intamin	Europe (LI)
4	Fury 325	Carowinds	Charlotte, N.C., USA	2015	671	B&M	Europe (CH)
5	Nitro	Six Flags Great Adventure	Jackson, N.J., USA	2001	650	B&M	Europe (CH)
2014							
1	Millennium Force	Cedar Point	Sandusky, Ohio, USA	2000	1139	Intamin	Europe (LI)
2	Bizarro	Six Flags New England	Agawam, Mass., USA	2000	1049	Intamin	Europe (LI)
3	Expedition GeForce	Holiday Park	Hassloch, Germany	2001	764	Intamin	Europe (LI)
4	Diamondback	Kings Island	Mason, Ohio, USA	2009	579	B&M	Europe (CH)
5	Nitro	Six Flags Great Adventure	Jackson, N.J., USA	2001	563	B&M	Europe (CH)
2013							
1	Millennium Force	Cedar Point	Sandusky, Ohio, USA	2000	1204	Intamin	Europe (LI)
2	Bizarro	Six Flags New England	Agawam, Mass., USA	2000	1011	Intamin	Europe (LI)
3	Expedition GeForce	Holiday Park	Hassloch, Germany	2001	598	Intamin	Europe (LI)
4	Nitro	Six Flags Great Adventure	Jackson, N.J., USA	2001	596	B&M	Europe (CH)
5	Apollo's Chariot	Busch Gardens Williamsburg	Williamsburg, Va., USA	1999	542	B&M	Europe (CH)

Table 2
Amusement Today's Golden Ticket Awards – Top 5 Steel Roller Coasters (2013 – 2017) and Country of Origin (adapted from Amusement Today, 2017)

Of the 25 awards that have been granted over the 5 year timeframe, 24 have been awarded to a European manufacturer, equating to 96% of the best roller coasters in the world being of European origin. When looking at the top roller coaster for each year over the 5 year timeframe, 5 out of 5 have been awarded to a European manufacturer, equating to a 100% winning margin overall. This specifically highlights the importance and popularity of the ESRCI from an end user perspective. It is also worth noting that, in each case, the winning roller coaster has been located in the USA, despite the manufacturer originating from Europe. As such, the ESRCI becomes of particular interest as an export of the European economic region, to both the US and global amusement markets.

While polls such as the Golden Ticket Awards and other member surveys such as the National Amusement Park Historical Association (NAPHA) are very much subjective in nature, many parks have been found to have an interest in the survey findings and may incorporate the results into their publicity materials (Futrell, 2017). Moreover, these awards may also be showcased online by manufacturers through their websites and social media accounts

(Intamin Amusement Rides, 2017; Bolliger & Mabillard Instagram, 2016) or while exhibiting their products at international trade shows and conventions.

One such convention in particular, is the annual International Association of Amusement Parks and Attractions (IAAPA) trade show and convention held in Orlando, Florida, USA. The show is seen as the one-stop destination for leisure and attractions industry professionals, including owners, operators, suppliers, investors, and developers from all over the world (IAAPA, 2017). As such, through convenience sampling, the list of exhibitors present at IAAPA 2017 was chosen as the sample population for this study. By attending the convention and making use of the printed exhibitor's list as provided to show attendees, a total of 1108 exhibitors [1] from 40 countries [2] across the world were identified to be present.

From this sample, a total of 12 European countries were represented by 104 European exhibitors across all areas of amusement. From the general European population, a final 23 European-based, steel roller coaster manufacturer exhibitors were identified, representing 6 European countries.

For the remainder of this study, we will therefore focus primarily on these 23 exhibitors and the role that they play as representatives of the ESRCI not only in the USA, but also, on a global scale.

The European Steel Roller Coaster Industry

As the recognized sign of amusement, the roller coaster enjoys both American and worldwide cultural coinage (Anderson, 1999) with the steel roller coaster having been identified as the most desired new attraction in 2016 (discussed in section 1).

Establishing the reach of the ESRCI in the global amusement market is of particular interest as it may indicate to what extent the steel roller coaster has become an export of the European economic region.

The Roller Coaster Database (RCDB), a census-like database that provides detailed information on almost any roller coaster produced since the early 20th century in addition to information on all the manufacturers that are, or have been, active in the roller coaster industry (Timmermans et al., 2012)(Marden, 2018) is used in this endeavour. By making use of RCDB, we identify a total of 43 ESRC manufacturers active in the manufacturing and/or design of roller coasters varying from simple to complex rides. Of these 43, 23 are discussed in this paper, based on their presence at IAAPA 2017. This accounts for 53% of all ESRC manufacturers (in 2017) and ensures a majority representation of the industry.

Moreover, RCDB allows us to identify all operational roller coasters (up until the end of 2017) and their country of operation for each one of the 23 manufacturers that form part of our ESRCI population. A summary of these 23 manufacturers along with their country of origin, the number of operational roller coasters (end 2017) as well as the number of countries of operational roller coaster instalments is summarised in table 3.

Manufacturer	Country of Origin	Number of Operational Roller Coasters (end 2017)	Number of Unique Countries of Operational Roller Coaster Instalments
ABC Rides	CH	2	2
Bolliger & Mabillard (B&M)	CH	99	15
C & S	IT	1	1
Doppelmayr	AT	0	0
Eos Rides	IT	18	10
Fabbri	IT	19	9
Gerstlauer Amusement Rides GmbH	DE	77	22

Gosetto	IT	1	1
Intamin Amusement Rides	LI	119	26
KumbaK "The Amusement Engineers"	NL	1	1
Mack Rides GmbH & Co. KG	DE	104	26
Maurer Rides GmbH	DE	54	30
Mondial	NL	0	0
Preston & Barbieri	IT	11	11
Ride Engineers Switzerland	CH	0	0
Sartori Rides International	IT	9	8
SBF Visa Group	IT	151	47
Sunkid Heege GmbH	DE	64	9
Technical Park	IT	2	2
Vekoma	NL	238	46
Wiegand	DE	214	38
Zamperla	IT	222	52
Zierer	DE	129	28

Table 3
ESRC Manufacturer Country of Origin, Number of Operational Roller Coasters (end 2017) and Number of Unique Countries of Operational Roller Coaster Instalments (by the authors)

From table 3, a total of 6 European countries are identified as being represented by the ESRCI population, including Austria (AT), Switzerland (CH), Germany (DE), Italy (IT), Liechtenstein (LI) and the Netherlands (NL). A summary of each country's representation is visible in figure 2 with Italy being in the lead with 9 representatives.

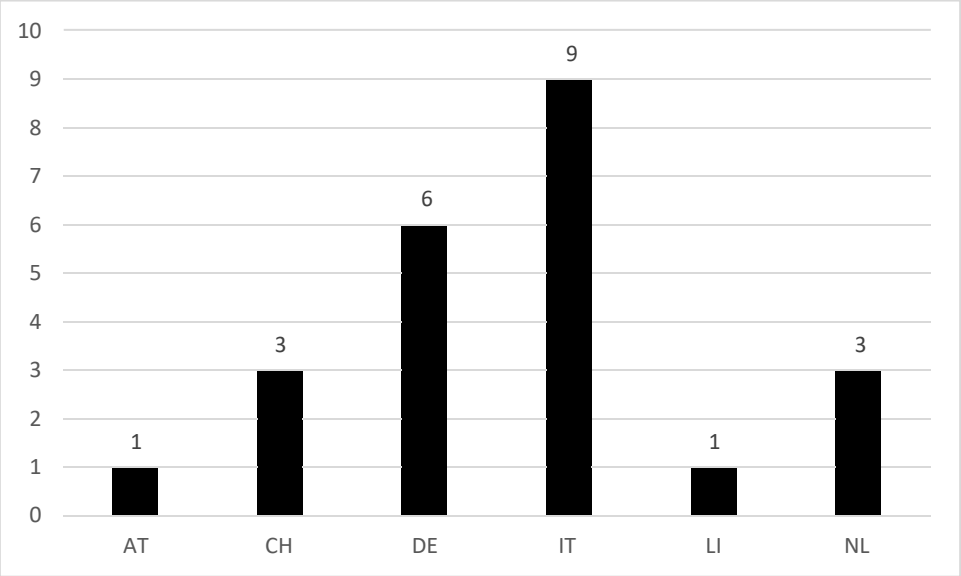

Fig. 2
ESRCI Representatives Grouped by Country of Origin (by the authors)

A total of 1535 roller coasters manufactured by the ESRCI were identified as operational at the end of 2017, spread over 89 countries. Despite Italian manufacturers being the most represented (as visible in figure 2), their German counterparts outnumber them when it comes to the total number of roller coasters delivered on a per country basis (visible in figure 3). German produced steel roller coasters are collectively thus the most manufactured product of the ESRCI.

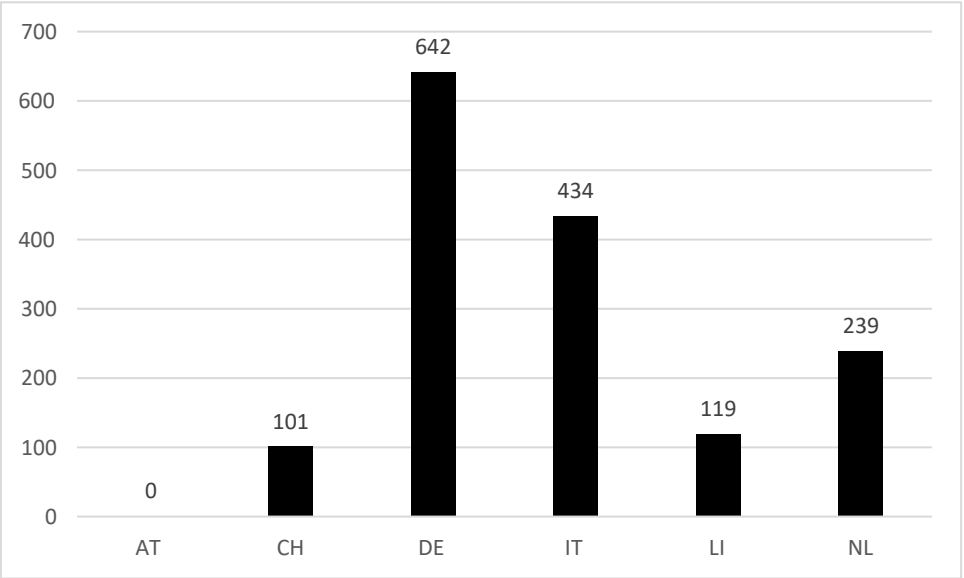

Fig. 3
Number of ESRCs in operation (2017) per Manufacturer Country (by the authors)

When looking at the all-time, top consumer of European produced roller coasters, however, the USA is in the lead with a total of 319 ESRCs, or 21% of the industry deliverance, being present in the country as visible in figure 4. Germany and China take 2nd and 3rd position with 192 (12%) and 95 (6%) ESRCs operational in each country, respectively.

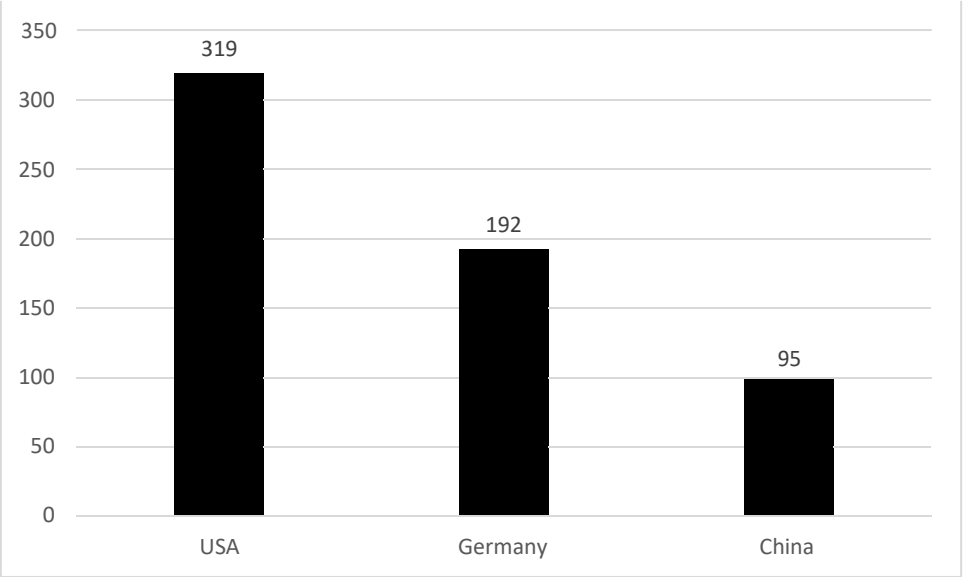

Fig. 4
Top 3 ESRC Countries of Operation End 2017 (by the authors)

It is interesting to note that each of the countries in the top 3 represent a major continent both outside (USA and China) as well as inside (Germany) Europe. The ESRCI, as a whole, can thus be seen as a true global export of the European economic region.

African Journal of Hospitality, Tourism and Leisure, Volume 7 (3) - (2018) ISSN: 2223-814X

When evaluating the trend over the past 5 years of the top 3 countries as is visible in figure 5, demand for ESRCs shows positive growth in each case, with Chinese demand predicted to possibly overtake German demand in coming years.

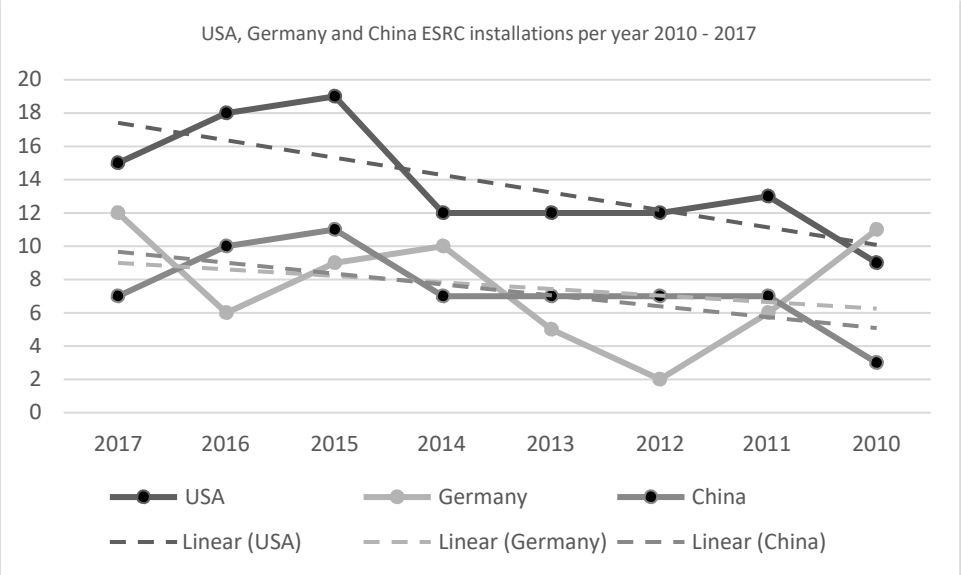

Fig. 5
USA, Germany and China ESRC installations per year 2010 – 2017 (by the authors)

Similar cases of increased demand have been predicted for Turkey and India in the coming years as the middle class in these countries is growing and found to have more money to spend on entertainment and amusement (Spieldiener, 2015).

This analysis thus highlights the USA as the most popular importer of ESRCs with emerging markets such as China, Turkey and India predicted as future popular importers.

Despite the popularity and global demand for steel roller coasters, and ESRCs in particular, similar to almost any other infrastructure, roller coaster infrastructure does eventually also get old. Unlike conventional infrastructure, however, roller coasters may undergo a digital experience "makeover" by incorporating VR into the experience.

In such an event, a VR experience overlay may generate new interest in older infrastructure and, as mentioned earlier, attract new and/or return visitors. Due to the versatility of the technology, various approaches may be taken to provide immersive experiences capable of redefining a rider's visual and auditory experience while in motion, ultimately enhancing the theme and experience of not only the roller coaster itself, but also the park. VR can, however, be applied to various derivations of a steel roller coaster to provide an enhanced experience too – a discussion on this follows next.

The Virtual Reality Enhanced Steel Roller Coaster and its Variants

VR can be described as the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors (Oxford Living Dictionaries, 2017).

With numerous types of VR headsets readily available directly to the public, *Virtual Reality* is already becoming a *tangible reality* for many – all in the comfort of their own home, by making

use of their own smartphone. Google Trends indicates a steady increase for the search term "Virtual Reality" over the past 5 years, with a notable spike occurring during 2016 (Google Trends, n.d.).

This spike coincides closely with the introduction of the world's first VR enhanced roller coaster, Alpenexpress at Europa-Park in Germany, in September of 2015 (Kleiman, 2015). According to the co-creators of the Alpenexpress' VR experience overlay, VRCoaster GmbH & Co. KG, even small or aged coasters can simulate amazing, adrenalin-filled rides, with increased virtual heights, dimensions and speed by incorporating VR (VRCoaster, 2015).

In certain cases, however, parks may choose to invest in VR roller coaster simulators instead of real roller coasters, thereby replacing the need for physical roller coaster infrastructure. These 'fauxller coasters' may prove to be an ideal solution for budget and space constrained parks that would like to make an experience more accessible to a wider audience (such as families).

Furthermore, in section 1 (figure 1), VR simulators (in all shapes and sizes) were identified as the 4th most desired new attraction for park owners in 2016. By combining the popularity and demand for both steel roller coasters and VR simulators, however, a best of both worlds experience may be provided for end users with the introduction of hybrid, VR enhanced roller coasters as illustrated in figure 6.

Fig. 6
VR Enhanced Steel Roller Coaster (middle) as a Hybrid Product Composed of an Original Steel Roller Coaster (left) and VR Roller Coaster Simulator (right) (by the authors)

Timmermans et al. (2012) note that the roller coaster industry in particular has a lust for diversity, implying that there is a demand for both the more traditional (original roller coaster) and new type of roller coaster (VR simulators). VR can arguably thus be seen a complimentary asset to existing roller coaster infrastructure and the amusement industry within a bigger scope.

With the ESRCI delivering some of the world's most sought-after roller coasters, these products are possibly some of the best candidates to combine a VR experience overlay with. As such, launching an investigation into establishing to what extent VR has already impacted these manufacturers and their products, may give an indication of the future trends of VR and its use in the steel roller coaster industry at large.

Virtual Reality and its effect on the European Steel Roller Coaster Industry

As mentioned earlier, the world's first VR enhanced roller coaster was introduced in 2015 at a European park (Europa-park) when VR was added to a European steel roller coaster (Alpenexpress by Mack Rides GmbH & Co. KG) by a European company (MackMedia a,

division of Mack Rides GmbH & Co. KG, and VR Coaster GmbH & Co. KG, a German start-up company owned by Mack Rides)(Kleiman, 2015; VRCoaster, 2015).

Despite maintenance and the cost of VR equipment having appeared as an initial obstacle to VR adoption on roller coasters (Rochereuil, 2016), numerous parks followed suit by introducing VR to their existing roller coaster infrastructure. Among these roller coasters were several produced by the ESRCI.

Table 4 indicates which of the 23 ESRC manufacturers that form part of this study have had at least 1 of their roller coasters retrofitted with VR (at the end of 2017) and in which year this first occurred.

Manufacturer	VR Affected in 2017?	First Year Affected
ABC Rides	No	-
Bolliger & Mabillard (B&M)	Yes	2016
C & S	No	-
Doppelmayr	No	-
Eos Rides	No	-
Fabbri	No	-
Gerstlauer Amusement Rides GmbH	Yes	2016
Gosetto	No	-
Intamin Amusement Rides	Yes	2016
KumbaK "The Amusement Engineers"	No	-
Mack Rides GmbH & Co. KG	Yes	2015
Maurer Rides GmbH	No	-
Mondial	No	-
Preston & Barbieri	Yes	2017
Ride Engineers Switzerland	No	-
Sartori Rides International	No	-
SBF Visa Group	No	-
Sunkid Heege GmbH	No	-
Technical Park	No	-
Vekoma	Yes	2015
Wiegand	No	-
Zamperla	Yes	2017
Zierer	Yes	2016

Table 4
ESRCI VR Affected and Year of First Occurrence (by the authors)

From the results, we can see that 8 manufacturers' rides have been affected by the addition of VR by the end of 2017. This implies that over a span of 3 years, 32% of ESRC manufacturers have been affected by VR. Furthermore, when launching an investigation into the developers of the VR experience overlay of the ESRC manufacturers that have been affected by VR addition to their products, a vast majority's roller coasters' VR experience overlay has been designed by German start-up company, VR Coaster GmbH & Co. KG as is visible in table 5.

Manufacturer	Affected by VR?	Any VR Experience Overlay Provided by VRCoaster?	Number of VRCoaster VR Experience Overlays
Bolliger & Mabillard (B&M)	Yes	Yes	4

Gerstlauer Amusement Rides GmbH	Yes	Yes	2
Intamin Amusement Rides	Yes	Yes	3
Mack Rides GmbH & Co. KG	Yes	Yes	4
Preston & Barbieri	Yes	Yes	1
Vekoma	Yes	Yes	8
Zamperla	Yes	No	-
Zierer	Yes	Yes	2

Table 5
ESRC Manufacturers Affected by VR and VRCoaster's Contribution (by the authors)

At the end of 2017, European-based company VRCoaster has thus developed VR experiences spanning 13 countries, 38 rides, 33 steel roller coasters of which 24 (73%) were manufactured by the ESRCI (VRCoaster, 2015).

In the exceptional case of Zamperla, however, an internal technology division "Z+" was launched at IAAPA 2017 (Bederka, 2017), thereby insourcing the development of VR experiences, possibly eliminating the need to make use of an external VR provider such as VRCoaster. This may prove to be a viable alternative strategy for ESRC manufacturers that would like to incorporate VR offerings with their own roller coasters right from the start, thereby also expanding their own product range.

While VR product development and integration strategies are still in the early stages of exploration, as it currently stands, VR can undoubtedly be identified as a key role player and technology for further consideration in the roller coaster industry going forward.

Conclusions and Discussion

In this paper, the roller coaster was pointed out to be a complete representation of the culture of American amusement, with steel roller coasters in particular being identified as the most sought-after addition to amusement and theme parks over the next 2 to 3 years (as indicated in 2016).

Annual ceremonies such as the Golden ticket awards showcase some of the industry's best steel roller coasters and for the past 5 years (2013 – 2017), the top 3 awards have been bestowed upon ESRC manufacturers. As a result, the ESRCI becomes of particular interest as an export of the European economic region having established itself well not only within the US, but also global amusement markets.

From a selection of 23 ESRC manufacturers, identified through convenience sampling as exhibitors at the 2017 IAAPA trade show and convention in Orlando, USA, we found a representation of 6 countries with 1535 operational steel roller coasters located in 89 countries around the world.

Through further exploratory analysis, German-based ESRC manufacturers were found to collectively have the highest product yield, with over 600 German roller coasters being in operation all over the world at the end of 2017. When looking at consumption of ESRCs, however, the USA is the global leader with over 300 ESRCs active in the country. While Germany follows in second place, with over 190 active ESRCs in the country, emerging markets such as China (the third biggest consumer of ESRCs with over 90 active in the country at the end of 2017), Turkey and India may very well show an increase in demand for ESRCs in the coming years.

Despite the global impact and demand for ESRCs, roller coaster infrastructure, as any infrastructure, does eventually become outdated. With the introduction of VR, however, existing roller coasters and their infrastructure can be revitalised at a fraction of the cost of a complete rebuild by introducing a digital experience overlay (Louw, 2017a:135).

Since the introduction of the first VR coaster, the Alpenexpress (by Mack Rides) in Europa-Park, Germany by VRCoaster, 8 of the 23 ESRC manufacturers (35%) have had at least 1 of their operational rollercoasters retrofitted to incorporate VR. Moreover, with the exception of 1 case, each ESRC manufacturer, whose rides have been retrofitted to incorporate VR, has had a VR experience overlay developed for their roller coaster by the European-based, German VR start-up company, VRCoaster GmbH & Co. KG.

From this discussion, the global impact of not only the ESCRI is evident, but also that of the European VR roller coaster experience overlay. Both products can thus be seen as important exports of the European economic region.

With the integration of VR in both existing and new roller coasters, externally or internally to a manufacturer, this research has evidenced the infiltration of the digital disruption on yet another industry. As such, not only is the (Valich, 2015):

- World's largest taxi company owning no taxis (Uber);
- Largest accommodation provider owning no real estate (Airbnb);
- Largest phone companies owning no telecommunications infrastructure (Skype);
- World's most valuable retailer owning no inventory (Alibaba, Amazon);
- Most popular media owners creating no content (YouTube);
- Fastest growing banks having no actual money (SocietyOne);
- World's largest movie house owning no cinemas (Netflix);
- Largest software vendors not writing apps (Google, Apple);

But now possibly too, the

- Largest (VR) roller coaster experience providers owning no roller coaster infrastructure (VRCoaster).

Mars et al. (2017) do note that technology is changing us, making us smarter and subsequently also driving our thirst for liminal experiences. They predict that in the future, the technologized gaze will become increasingly interactive. This implies that we want to see and feel, we want sensory stimulation, less simulation, and we want more of the real. Tourism moves the consumer beyond a representation to an authentic experience. As such, it is noted that we can experience so much via technology, but not the extra-dimension of the real, the experience of being there. By combining VR (the technologized gaze) with the real (steel roller coaster), however, a best of both world experience can be delivered.

The lust for diversity and new product innovation in the roller coaster industry would indicate that original roller coasters, virtual reality simulator roller coasters and VR enhanced roller coasters will be a welcome addition as they may cater to the diverse needs of a wider audience.

Collectively, however, it is arguable that VR enhancements to the traditional roller coaster may be able to achieve an outcome superior to that of its constituent parts, i.e. a VR simulator or traditional roller coaster, would be able to do in isolation. This experience may ultimately draw new and return visitors to amusement and theme parks, leaving visitors satisfied with the 'new' experience on the whole.

Naturally, future work could include gaining a better understanding of how VR additions to existing roller coasters affect park visitor numbers with prior studies having indicated positive results of introducing new attractions lasting up to 2 years (Cornelis, 2010). Furthermore, by focusing only on the ESRCI, a limited view is given relating to VR adoption in the bigger scheme. Conducting a study on the global adoption of VR by the roller coaster industry as well as identifying when and how to implement the technology, may provide further direction for those considering implementing VR with steel roller coasters or other amusements at large. Lastly, the various managerial implications of introducing VR to steel roller coasters and its impact on manufacturers, parks and visitors may provide further guidance when siding for, or against, the implementation of the technology.

By adopting a manufacturer and industry centric point of view on the subject matter, this paper does however, provide a point of departure to advance future industry and scholarly discourse in the understanding of VR usage with steel roller coasters and whether VR poses a threat to new roller coaster infrastructure development, is a complimentary asset to existing roller coaster infrastructure or is merely a passing fad.

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Endnotes

[1] In the 6 cases of exhibitors listing more than 1 address, i.e. an address in the USA and an address in Europe, the exhibitor is counted twice – once for each country representation.

[2] Hong Kong is included in the count for China throughout.