MSc Program
Engineering Management

Optimization of the scenario based strategy planning process for the Instrumentation and Test Systems Racing market at AVL List GmbH

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“Master of Science”

supervised by
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Affidavit

I, **ING. MARTIN MONSCHEIN**, hereby declare

1. that I am the sole author of the present Master's Thesis, "OPTIMIZATION OF THE SCENARIO BASED STRATEGY PLANNING PROCESS FOR THE INSTRUMENTATION AND TEST SYSTEMS RACING MARKET AT AVL LIST GMBH", 69 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted the topic of this Master's Thesis or parts of it in any form for assessment as an examination paper, either in Austria or abroad.

Vienna, 12.03.2021

_____
Signature

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At this point I want to thank everyone who supported me during this program as well in generating this thesis:

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Abstract

Besides Marketing, Motorsports is an effective platform for the automotive industry to develop and test new technologies under extremely competitive conditions. Shorter development cycles and highly optimized performance and durability require the right set of tools which eventually find their way into the main automotive development processes.

AVL List GmbH is the major supplier of instrumentation and test systems for all elements of the powertrain as well as vehicle components for all premium racing series. In order to be able to support the fast-changing development and testing requirements of the race teams the availability of the right tools is essential. To develop these tools and having the right test systems portfolio, it is vital for to anticipate changes ahead of time.

To be able to adapt to the volatile requirements of the racing market a scenario planning approach was introduced in the Racing Business Segment at AVL in 2016.

This master thesis provides a detailed overview of the currently implemented scenario planning process and evaluates the quality of the scenarios in terms of the estimated probability and business severity for the timeframe 2017- 2020.

The scope of this thesis was also to improve the current shortcomings in the current business forecast suitable for proper midterm planning by the introduction and integration of an additional scenario-based forecasting technique.

This paper outlines an approach to combine elements from different scenario planning methods to create a framework tailored to the specific forecasting requirements.

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1 INTRODUCTION

Executives around the globe agree that strategy is important. But at the same time, it is also feared because it forces them to confront the future, which to a certain point, is unknown. Making decisions about the future always bears the risk of cutting out possibilities and options that might have been right after all (Martin, 2014).

Strategy definition is very often treated as a one-time event that ends in the creation of a vision and mission statements and the box is checked. With this approach, there is a high likelihood in failing to meet the targets that have been defined. Several more elements must be considered in order to be successful.

Figure 1: Six vital elements to successful strategic planning (Overgaag, 2020).

Responding to unanticipated opportunities and threats requires agility in decision making and flexibility in the set course. Insights and knowledge gained from the successes and failures in these responses are part of the strategy development. It is very important to understand that strategic planning is an ongoing process that requires time, effort and continual reassessment (Cote, 2020).

Especially when times and market situations are challenging and uncertain, a lot of businesses are forced to sail by sight because they do not have a solid strategy planning process in place that supports the navigation. But as uncertainty becomes rather the norm than the exception, a solid strategy and associated planning process is essential.

Based on the specific market, there are several methods and tools for strategic planning that can be applied. The process of identifying the right approach will require

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iterations resulting in gaining insights and knowledge. The goal is to establish a process that provides the required results while also being time-efficient and robust in usability. This ensures that it is implemented as a regular standard business process rather than being put on the short end of the priority list.

1.1 Objective

The main focus of this thesis it the improvement of the AVL RACING scenario planning process. This process should serve as a robust tool to address the challenges of uncertainty provided by the motorsports market. A profound evaluation of the existing process is used to identify the areas for improvement. Scenarios created by the insights of industry experts to derive required actions are combined with defined future events that are quantified by insights gained out of historical data. This method is then validated by the application on previous scenario planning processes. Another objective is to generate a user-friendly template that can be updated with the availability of new business data and utilized in the monitoring as well as future planning processes. The improvement in usability is a key element in making sure that the tool is utilized properly, especially with new or changing participants in the scenario planning process and for further rollout in the organization. Another outcome is recommendations for further future process improvements.

This work will focus on the motorsports market that is currently addressed by AVL RACING, but not potential extensions of this market.

1.2 Problem Formulation

Strategy planning and business forecasting are very important components in defining required resources and actions going forward. Many businesses rely mainly on their experience rather than profound processes for this activity, which makes it very subjective and in addition very difficult to introduce to new or changing personnel. Solely utilizing expert estimations rather than quantifiable historical data increases the possibility for error and is also difficult to further improve in future iterations. This is especially the case for engineering companies that lack economic and business background. Poorly defined methods are lacking forecast quality as well as accuracy and most likely end up in a “have to be done” process rather than resulting in the gain of important direction. This will also not be accepted by senior management.

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1.3 Company introduction

The AVL List GmbH is the world's largest independent company for development, simulation and testing technology of powertrains for passenger cars, trucks and large engines. It was founded in 1948 with the headquarters in Graz, Austria and now operates with 45 affiliates and employs approximately 11,500 people worldwide. Approximately 10% of the annual turnover is reinvested in company financed research to provide industry-leading technologies and service based on the highest quality and innovation standards (AVL, 2021).

AVL is structured into the strategic business units Powertrain Engineering (PTE), Instrumentation and Test Systems (ITS) and Advanced Simulation Technologies (AST):

- *PTE*: Powertrain Engineering focuses on the development and improvement of all kinds powertrain systems and elements and is a competent partner to the automotive industry.
- *ITS*: This business area is responsible for the development, marketing and support of instrumentation and test systems required for powertrain and vehicle testing.
- *AST*: Advanced Simulation Technologies are simulation software tools developed for the design and optimization of powertrain systems in all phases of the development process.

In 2012 AVL RACING was introduced to cater to the specific requirements of the motorsports market, harnessing all AVL competencies. Build around the five segments Simulation, Engineering, Manufacturing, Testing and Race support, AVL RACING is the integrated partner at every stage of the development process (AVL, 2021).

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Figure 2: AVL Full Vehicle Test System (AVL, 2017)

In this thesis the AVL RACING segment “Testing” will be evaluated. This segment is responsible for the development, marketing and support of testing systems for components, power units, powertrains up to the full vehicle.

1.4 Thesis Outline

This master’s thesis is structured into six main chapters, including several sub-chapters. An overview, including the setting of the context and outline of the problems that need to be addressed are provided as an introduction into the topic in chapter 1.

Chapter 2 covers the history of strategy development, different approaches to strategic planning and requirements of different markets. An overview of the automotive market and the specific requirements of the motorsports market is provided in order to outline the challenges of strategic planning in this industry.

A detailed explanation of the AVL RACING scenario planning process, including the review of the quality in scenario hit rates and business forecast from previous scenario planning processes is the content of chapter 3.

The approach of trend-impact analysis to improve the business forecast quality is covered in chapter 4. The process of extracting valuable information from historical

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business data to quantify possible future events, combining these events to future scenarios and generating a business forecast it outlined in this chapter as well.

Chapter 5 includes a review of the business forecast results and accuracy improvements when combined with the scenarios from the previous AVL RACING scenario planning processes.

In the final chapter 6 the findings are summarized and conclusion as well as future improvements defined that should serve basis to further introduce this approach to other business segments.

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2 STRATEGY PLANNING

2.1 Strategy

What is strategy?

"Strategy is about shaping the future – it is about how people attain desirable ends with available means". (Mckeown, 2016, p. 12)

Everyone has already used strategies to get what he or she wants. Whether getting an education to land/obtain a certain job or saving money for a new car – something was done to reach a future goal. Organizations formulate and implement strategies to reach their business goals in either steady or dynamic markets. To better understand the purpose as well as the limitations of modern business strategy, it is beneficial to take a short look at the history of strategy.

2.2 History

The word strategy is derived from the Greek word *strategos* which means general. In this respect the origins of strategy lie with generalship and the qualities that made for effective leadership. This approach developed in the fifth century BC during the Athenian enlightenment to explain events based on human behavior and decisions (Freedman, 2013).

Other explanations of military strategy and tactics related to warfare emerged out of Asia. Sun Tzu's book *Art of War* (5th century BC) is one of the most famous studies of strategy ever written and contained a detailed explanation and analysis of the Chinese military, including weapons, strategy, rank and discipline and has strongly influenced military thinking, business tactics and beyond.

Corporate strategy emerged as a field of study and practice after the Second World War.

Alfred D. Chandler Jr., a professor of business history at the Harvard Business School and Johns Hopkins University, began looking at large-scale enterprises in the early 1960's. During the examination of the four companies du Pont, General Motors, Standard Oil of New Jersey and Sears, Roebuck and Co. he found that the modern decentralized managerial structures have been developed in response to the corporation's business strategy (Chandler, 1962).

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In 1965, Igor Ansoff created the first systematic model as an instrument for strategy development (Ansoff, 1965). He is also described as the father of strategic management and his theories were based on his management experience from Lockheed. His famous product/market matrix, the Ansoff Matrix (Ansoff, 1957), is a strategic planning tool to develop diversification strategies in the context of four different growth alternatives.

Figure 3: Diagram of the Ansoff Matrix (Riley, 2016)

Henry Mintzberg, a Canadian professor and author on business and management, claimed that most management and strategy education was obsessed with numbers and the attempt to make strategy a science. He argues that only few strategies have been fully realized as intended. He believes that strategy formation is judgmental designing, intuitive visioning and emergent learning.

Michael Porter, an American academic and leading authority on competitive strategy, has continued the more analytical and mathematical approach to strategy. He created the well-known *Porter's five forces analysis* (Porter, 1979), an instrumental tool for strategy development today. It analyzes the level of rivalry within the industry, entry barriers, power and impact of suppliers, power of customers and threat of substitute services or products in order to build defenses against these competitive forces.

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Figure 4: Five Forces Model (Business-to-you, 2016)

2.3 Strategic Planning

Organizations that want to be successful must be able to respond to the challenges that the market presents. One response might be to keep improving what they have always done, but this only works if change is incremental. In dynamic markets, where change is rapid, organizations are required to think, act and learn strategically as never before. Strategic planning requires deliberation informed by effective information, definition of goals, the development and choice among strategic alternatives and successful implementation (Bryson, 2018).

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Figure 5: The ABCs of Strategic Planning (Bryson and Alston, 2004)

The development and execution of a strategic plan typically consist of the following main steps: strategy formulation, strategy implementation and strategy evaluation.

The purpose of the strategy formulation step is to create a set of strategies in response to strategic issues or to achieve goals (Bryson, 2018).

The execution of a discerned strategy that best fits the organization's goals is the step of strategy implementation and determinant of success or failure (Jofre, 2011).

The purpose of strategy evaluation is to review the implemented strategy to decide on actions that will ensure that the goals are achieved. Actions may include the maintenance of successful strategies, modifications of less successful ones or the elimination of undesirable strategies (Bryson, 2018).

The main benefit of strategic planning for organizations is the ability to proactively react to market changes and hence ensure long-term success. An annual global survey amongst executives about the management tools in terms of usage and satisfaction ranks strategic planning at the top:

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	Usage	Satifaction
Strategic Planning	48%*	4,03
Customer Relationship Management	48%*	4,01
Benchmarking	46%*	3,94
Advanced Analytics	42%*	4,06
Supply Chain Management	40%*	4,05
Customer Satisfaction Systems	38%*	4,03
Change Management Programs	34%*	3,90**
Total Quality Management	34%*	4,09*
Digitial Transformation	32%	4,07
Mission and Vision Statements	32%	4,00
Employee Engagement Systems	31%	3,87**
Core Competencies	30%	3,92
Internet of Things	30%	4,07
Balanced Scoreboard	29%	3,93
Business Process Reengineering	28%	4,02
Customer Segmentation	27%**	4,06
Strategic Alliances	25%**	3,93
Agile Management	24%**	4,00
Mergers and Acquisitions	24%**	3,90
Organizational Time Management	22%**	3,96
Prize Optimization Models	20%**	4,06
Scenario and Contingency Planning	19%**	3,99
Customer Journey Analysis	18%**	4,06
Complexity Reduction	17%**	3,88
Zero-Based Budgeting	10%**	3,82**

*Significantly above the overal mean (usage=30%, satisfaction=3,99)
**Aignificantly below the overal mean

Figure 6: Management tools usage and satisfaction rates (Bain Management Tools & Trends survey, 2017)

2.3.1 Incremental Planning

Incremental planning is derived from the concept of “logical incrementalism” – or incrementalism (Quinn, 1978). This strategic approach is the most common among large and small organizations. It does not follow a very detailed analysis approach to strategy formulation. Business growth is forecasted in a rational and incremental way based on experience from the past, research and development activities are based on logical extensions of the current portfolio and there is an ongoing focus on cost reduction which might lead to only incremental results (Burrus, 2015).

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Senior managers and shareholders are accustomed to incremental plans and therefore they are widely accepted. A related strength of the incremental planning approach is that a series of small decisions, guided by the mission and direction, can accumulate to major changes over time (Bryson, 2018).

A major weakness of the incremental planning approach is that staying focused on small or incremental changes bears the risk of missing major new technology trends or even industry disruption. This could lead to falling behind the competition a little more every year and slowly failing like the companies Kodak, Polaroid, Motorola and many others did throughout the 1990s (Burrus, 2015).

In rather steady markets, where companies have an unassailable leadership position, incremental planning might still be applicable. But deregulation, technological upheaval, globalization and social change are overturning the status quo (Hamel, 1996).

2.3.2 Transformational Planning

Transformational planning is using the period of unprecedented disruption and the forces of change as an opportunity to drive innovation and accelerate business growth. While it is important to be able to react and respond to change, the focus is on anticipating future trends and choosing to be the disrupter rather than waiting to be disrupted (Burrus, 2015).

Strategies born from transformational planning often result in business transformation. Options for transformation are, for example, transactional restructuring, where the changes to the business involve joint ventures or partnerships which allow companies to share the risk of expansion. Another option is business model innovation via the development of completely new products or services to enter new geographic markets or a significant reorganization of the operating model (Baker & McKenzie, 2014).

A global survey of executives shows that 33% of the respondents from the automotive industry see a priority in business model innovation:

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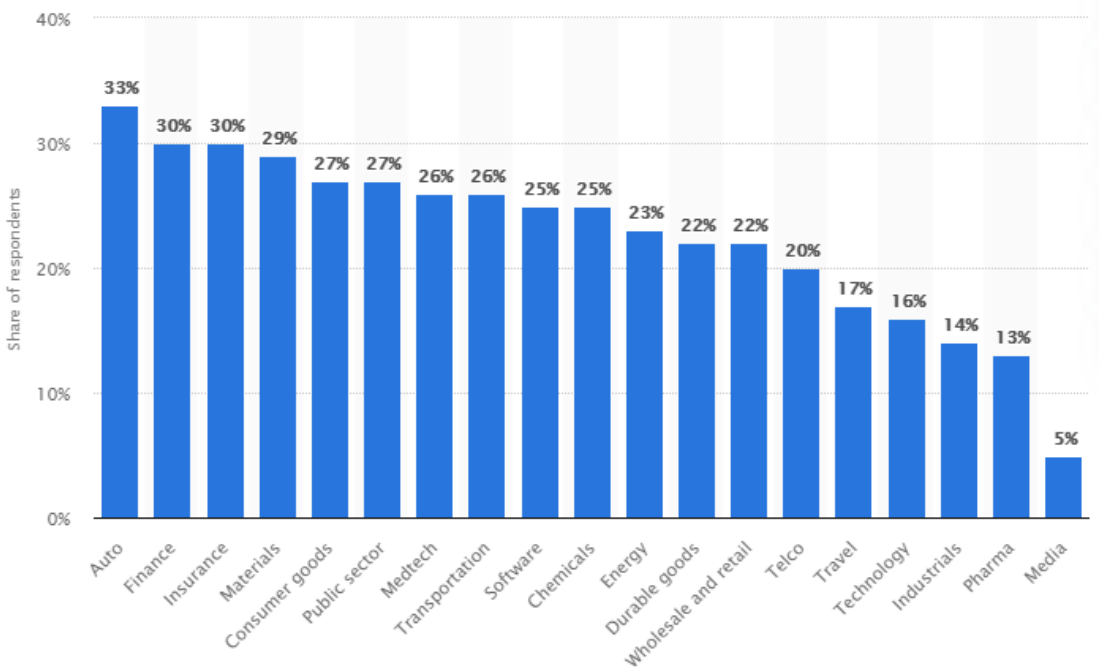

Figure 7: Share of business leaders that prioritize business model innovation as of 2019 (Statista, 2020)

Companies that have been in business for decades have the tendency to rely heavily on experience from the past and are more reluctant to change. The responsibility to create strategy lies with the senior managers, who have been with the company for a long time creating big top-down plans rather than involving the ranks of middle management where there are people with more revolutionary thinking. But experience is only valuable if the future is somewhat like the past. But industry after industry is changing and hence the requirement for strategic planning (Hamel, 1996).

2.4 Scenario Planning

"Scenario planning is inherently a learning process that challenges the comfortable conventional wisdoms of the organization by focusing attention on how the future may be different from the present". (Schwartz, 1991, p. 45)

The concept of scenarios has been around for quite a long time since people have always been interested in exploring the future of society. In strategic planning scenarios have their origins in the military employed by military strategists. Modern day scenario techniques emerged after the Second World War. The US Department of Defense needed direction in the development of new weapon systems. In the

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1950's Herman Kahn from the Rand Corporation began developing scenarios for a large-scale early warning system (Bradfield et al., 2005).

In the 1960s Royal Dutch/Shell introduced a new planning system called "Unified Planning Machinery" (UPM) to plan ahead for the next six years. But the long lead times for new projects in the oil industry revealed that a six-year planning horizon was too limited and therefore they decided to do experimental studies to explore the business environment of the year 2000. The outcomes of these studies predicted major changes in the oil market, oil prices and that expansion could not continue like in the past. These findings sparked the initiative to find a new plan and in 1971, scenario planning was developed as better framework to investigate the future. This new approach had Royal Dutch/Shell prepared for the 1973 oil crisis (Wack, 1985).

Organizations often plan with forecasts and projections. For short timeframes this works well enough and allows making decisions with reduced risk and uncertainty. Scenario planning is an instrument for dealing with the uncertainties in the future business environment and hence suited for long to medium-term planning. It has some key differences to traditional planning (Lindgren & Bandhold, 2003):

	Traditional planning	*Scenario planning approach*
Perspective	Partial, 'Everything else being equal'	Overall, 'Nothing else being equal'
Variables	Quantitative, objective, known	Qualitative, not necessarily quantitative, subjective, known or hidden
Relationships	Statistical, stable structures	Dynamic, emerging structures
Explanation	The past explains the present	The future is the *raison d'être* of the present
Picture of future	Simple and certain	Multiple and uncertain
Method	Determinist and quantitative models (economic, mathematical)	Intention analysis, qualitative and stochastic models (cross-impact and systems analysis)
Attitude to the future	Passive or adaptive (the future will be)	Active and creative (the future is created)

Figure 8: Characteristics of traditional planning compared with scenario planning approach (Lindgren & Bandhold, 2003)

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Over the years, many different techniques and methodologies for scenario planning have developed. One problem is that they lack paradigms which are accepted by most theoreticians and practitioners. There are some theories, principles and rules, but they are different and conflicting with each other (Martelli, 2001). These different methodologies are commonly classified into three main schools of techniques – the intuitive logics school, the la prospective school and the probabilistic modified trends school (Bradfield et al., 2005).

2.4.1 The Intuitive Logics School

The intuitive logics method is the most prominent in the scenario planning literature. This approach was proposed by Herman Kahn from the Rand Corporation and later used by Royal Dutch/Shell and therefore sometimes is referred to as the "Shell approach" (Amer et al., 2013).

The approach focused on the development of multiple scenarios to explore the limits of possibilities for the future rather than singular normative scenarios of an ideal future. It integrates political, economic, social, technological, ecological and legal (PESTEL) factors that will shape the future and analyzes the relationships between the critical uncertainties, important predetermined trends and the behavior of stakeholders in the predicted future (Wright et al., 2013).

The development of the scenarios typically takes place in a workshop relying on the participants' knowledge and viewpoints focusing on the full range of plausible futures (Derbyshire & Wright, 2017). The potential pitfalls are that participants tend to emphasize more recent events that have been prominent in the media, economic uncertainties as well as personal life experiences resulting in somewhat predictable and narrow scenarios (O'Brien, 2004). To overcome these pitfalls, it is very important to have a diverse group of participants in terms of background and experience that challenge each other in the scenario building.

2.4.2 The La Prospective School

The la prospective school was largely developed in the 1970s in France by Michel Godet during his time at the Department of Future Studies with the SEMA Metras Consulting group and improved during the 1980s at the Conservatoire national des arts et métiers with the support of several institutions (Godet & Roubelat, 1996).

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The concepts of this method of scenario construction include scanning and analysis of the present situation, studying the environment of the system, a simulation of the past based on the present situation and the environment and a representation of the reality in the future (Amer et al., 2013).

This strategic prospective approach utilizes a toolbox of problem-solving methods to support decision making. These tools are not equal to scientific calculations but should be a guide in asking the right questions, stimulate imagination and limit inconsistencies in the logic of the participants (Godet, 2000).

While the la prospective school also includes features from the intuitive logics school it also relies on mathematical tools which have their roots in the probabilistic modified trends school and therefore often is seen as a combination thereof (Bradfield et al., 2005).

2.4.3 The Probabilistic Modified Trends School

The probabilistic modified trends school utilizes the probabilistic forecasting methods trend-impact analysis and cross-impact analysis to generate scenarios of alternative futures (Rialand & Wold, 2009). It is based on the work of Olaf Helmer and Ted Gordon at the Rand Corporation in the USA (Amer et al., 2013).

Developed in the 1970s, the trend-impact analysis helps to answer particularly difficult questions in futures research. It is a forecasting method that extrapolates historical data via curve fitting into future trends and analyzes the impact of potential future events on this trend. These future events are defined by expert judgements and rated in terms of probability and impact. The future events can be seen as scenarios (Gordon, 1994).

The cross-impact analysis describes the interrelationship of developments and events. This is done by looking at the probabilities of individual events and the changes in probability when connecting them to each other. The set of events to be analyzed is compiled by inputs from experts in the investigated field. In a next step, the probabilities of the individual events are determined independently from each other in the forecasted future. After that, the conditional probabilities are estimated considering the other events with their probabilities, which is done for each combination (Gordon, 1994).

While there are apparent differences in these main schools of techniques, it is more difficult to distinguish between the intuitive logistics school and the la prospective

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school. Fundamental differences in all approaches are in the integration of external experts in the process and in the probabilities assigned to the scenarios (Bradfield et al., 2005).

Scenario characteristics	Intuitive logics methodology	La prospective methodology	Probabilitic modified trends (PMT) methodology
Purpose	Multiple, from a one-time activity to make sense of situations and developing	Usually a one-time activity associated with developing more effective policy and	A one-time activity to make extrapolitive prediction and policy evaluation
Scenario	Descriptive or normative	Generally descriptive	Descriptive
Scope	Can be either broad or narow, ranging from global, regional, country, industry to a specific	Generally a narrow scope but examines a broad range of factors within that scope	Scope is narrowly focuses on the probability and impact of specific events
Time frame	Varies: 3-20 years	Varies: 3-20 years	Varies: 3-20 years
Methodology type	Process oriented approach, essentially subjective and qualitative	Outcome oriented approach, which is directed, objective, quantitative and analytical relying on complex computer	Outcome oriented approach, very directed, objective, quantitative and analytical using computer based extrapolative
Nature of scenario team	Usually an internal team form the organization for developing	Combination of some members from client organization	External teams, scenario developed by experts (external
Role of external experts	Experiences scenario practitioneer to design and facilitate the process. External experts are used to obtain their	Leading role of external expert using an array of proprietary tools for comprehensive analysis	Leading role of external expert usind proprietary tools and expert judgements to identify high impact unprecedented
Tools	Generic tools like brainstorming, STEEP analysis	Proprietary and strutural tools like Micmac, SMIC and Mactor	Proprietary tools like trenda impact and cross impact
Starting point	A particular management decision, issue or general	A specific important phenomenon of concern	Decisions/issues for which detailed and reliable time series
Indentifying key driving forces	Intuition, STEEP analysis, research, brainstorming techniques and expert opinion	Interviews with stakeholders and comprehensive structural analysis using sophisticated	Curve fitting to past time series data to identify trends and use expert judgement to create
Developing scenario set	Defining the scenario logics as organizing themes or principles	Matrices of sets of possible assumptions based on teh key variables for future	Monte Carlo simulations to create an envelope of uncertainty around base
Output of scenario exercise	Qualitative set of equally plausible scenarios in narrative form with strategic options, implications and ealry warning	Multiple quantitative and qualitative scenarios supported by comprehensive analysis, implications and possible	Quantitative baseline case plus upper and lower quartiles and adjusted time series forecasts
Use of probabities	No, all scenarios are equally probable	Yes, probability of the evolution of variables under assumptions sets of actors' behavior	Yes, conditional probability of occurrence of unprecedented and disruptive events
No. of scenarios	Generally 2-4	Multiple	Usually 3-6 epend on the no. of
Evaluation criteria	Coherence, comprehensivnesss, internal consistency, novelty, supported	Coherence, comprehensivness, internal consistency tested by rigorous	Plausible and verifiable in retrospect

Figure 9: Comparison of the principal scenario planning techniques (Amer et al., 2013)

2.5 Market Dynamics

"A market opposes buyers and sellers and the prices which resolve this conflict are the input but also, in a sense, the outcome of the agents' economic calculation." (Callon, 1998, p.3)

Market stability is influenced by numerous factors such as population, demography, income levels, technology, etc. Very few markets stay stable, although the rate of market change varies. Stable markets have a very low rate of change compared to dynamic markets that can change rapidly. But even stable markets are subject to

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sudden changes which makes complacent and reactive strategies dangerous. Examples of sudden changes would be an economic recession or a pandemic that affects everyone from large corporations to small businesses to individual consumers. Dynamic markets are far more volatile and rapid and continuous change is the norm. If the market is stable and the current business situation satisfactory, then planning and adapting can be done in a predictable way. But if the market is dynamic and the business situation needs to change, more creativity in the planning may be required (Mckeown, 2016).

2.6 Automotive Industry Market

The automotive industry in the past has been considered a rather stable market where innovation has been driven by advances in technology, materials, production and the regulations for fuel efficiency and emissions set by the governments. Vehicle sales mirrored economic growth (ACEA, 2020).

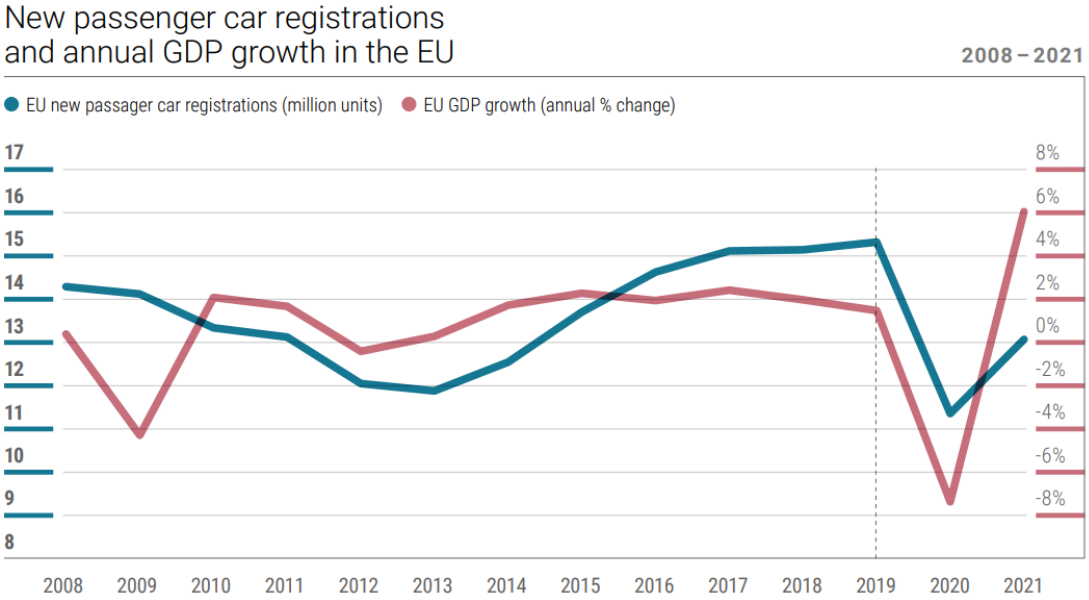

Figure 10 Source: ACEA, DG ECFIN; IHS Market

But the major five megatrends – technology breakthroughs, climate change and resource scarcity, demographic and social change, a shift in global economic power and rapid urbanization – that are challenging the business world are also key uncertainties in the automotive industry and transforming it into a dynamic marketplace (PWC, 2015).

The younger and technically savvy generation is a key driver in this transformation which puts an even higher focus on the mobility needs of the user and not the

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technical product itself. The automotive future will be electrified, autonomous, shared, connected and yearly updated (PWC, 2018).

2.7 Motorsports Market

The changes in the automotive industry have also a subsequent effect on the global motorsports market. In past decades, major car manufacturers as well as automotive-related companies were involved in motorsports to apply and showcase new technologies in grueling conditions and to market their products. The old adage “Win On Sunday, Sell On Monday” about the relationship between racing and car sales is not that straightforwardly applicable anymore.

Fierce on-track competition to maximize the performance within the given regulations drove the annual team budgets higher and higher. In Formula 1, the big three teams Mercedes, Ferrari and Red Bull are believed to have between 800 and 1000 employees and operating budgets exceeding $400 million annually (Saward, 2020).

Figure 11: 2019 overview of the Mercedes AMG Petronas F1 Team (Rencken, 2020)

This left smaller teams without realistic chance to compete for victories and forced major manufacturers like Honda to withdraw from the sport at the end of 2021. New Formula 1 regulations in 2021 will introduce an annual budget cap for the teams and further R&D restrictions for the Powertrain in 2022 to attempt to close the performance gap between the teams and to keep companies involved in the sport. These limitations limit the possibilities to stay at the forefront of automotive technology which used to be one of the reasons for car manufacturer involvement.

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Another challenge for the motorsports market is how to engage with future younger audiences who are requiring a more personalized viewing experience on demand rather than seeing the event live at the racetrack or just the broadcast on television. This millennial generation shows less interest in driving vehicles or even buying them. Potential explanations are that this generation prefers living in cities, using public transportation and social media instead of driving a car around to connect with friends (Standaert, Jarvenpaa 2016). Motorsports' major series need to balance the need to be socially responsible with the desire to maintain the appeal of the sport as a risky spectacle and be willing to adapt their racing formats and fan engagement activities to meet the audience's demands (Nielsen, 2017).

Racing series, such as Formula E which promotes the use of electric cars in city centers or the new Extreme E that is racing in remote environments to raise awareness for the climate crisis, are already addressing some of these challenges and at the same time challenge the status quo of the established major series. This presents new opportunities for the involvement of companies already participating in other series or new companies attracted by the new marketing opportunities adding to the high unpredictability of the motorsports market.

2.8 Chapter Summary

Strategies have been utilized throughout history in different fields, including businesses and organizations, to navigate and achieve desired goals and outcomes. As business environments and markets changed over time, so did strategy tools and methods to adapt accordingly. Increasing market dynamics, caused by disruption and unforeseeable events, and the unpredictability as a consequence thereof, make strategic planning more difficult. The global motorsports market is highly dependent on the general automotive market and the technology and marketing strategies the individual industry players pursue. On top of that, the motorsports market has to compete with other forms of entertainment and hence the interest of the viewers and spectators. This combination results in a high volatility, which puts high demands on strategic planning. In order to prepare various strategic options to navigate through the future, scenario planning provides a wider framework that, if properly utilized for the specific environment, can help organizations that operate in this field of business.

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3 SCENARIO PLANNING PROCESS

In 2014, the scenario planning approach was introduced in the AVL RACING business segment to increase the forecast quality of the volatile global racing market for test systems. This approach was based on the HHL-Roland Berger approach (Schwenker, Burkhard/Wulf, Torsten (2013): *Scenario-based Strategic Planning: Developing Strategies in an Uncertain World*, Springer Gabler, Wiesbaden). The approach was adapted to be more applicable to the specific environment and was composed of the following process steps:

1. Definition of Scope
2. Perception Analysis
3. Market Trend Analysis
4. Scenario Building
5. Strategy Definition
6. Monitoring

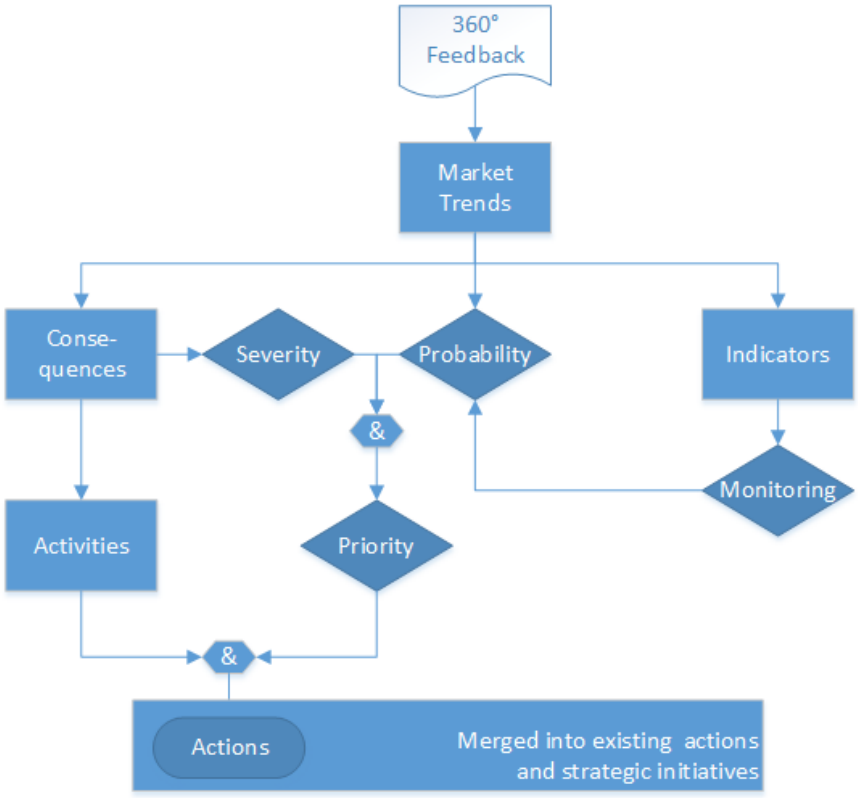

Figure 12: AVL scenario planning process

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The outcome of this planning approach is:

- Midterm order intake forecast (five years) → Input for operative resources and budget planning
- Portfolio adaptations → Input for R&D activity planning
- Market diversification → Input for Business Development, Sales and Marketing activities
- Brand and skill management → Input for strategic initiatives to strengthen the AVL RACING brand, customer perception and product/service delivery

3.1 Definition of Scope

In the process step Definition of Scope the target is to define the goal as well as the level of depth of the scenario planning approach.

Goal: The goal of this project is to develop future scenarios for the global racing industry in the next five years and their implications on AVL.

Strategic Level of Analysis: the focus is on the impact on the Business Unit level for AVL RACING testing, tools and services portfolio.

In addition, a panel of participants from AVL RACING is defined that is involved in all the process steps to maximize the output based on a variety of different angles and point of views.

3.2 Perception Analysis

To be able to gather as much input as possible from various angles of the racing market and to avoid blind spots, the focus is to identify internal (AVL) and external stakeholders (customers, partners, suppliers), which are invited to provide their ideas and input. For the internal stakeholders many different departments and geographic affiliates are considered. For the external stakeholders the goal is to incorporate stakeholders from different race series (e.g. Formula 1, NASCAR, WEC,…), sanctioning bodies (e.g. FIA, IndyCar,..), suppliers (e.g. Tier 1) and the motorsports media (e.g. Autosport, Race Engine Technology,…).

The stakeholders are invited to provide their input via e-mail, based on the following open-response questionnaire:

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Questions:

Please name important factors that will have crucial influence on the Racing Industry within the next five years and think of indicators to measure the factors. These factors can be

1) Political factors

2) Economic factors

3) Social factors

4) Technological factors

5) Ecological factors

6) Legal factors/regulations

The raw feedback from the stakeholders on this questionnaire is then structured into individual single statements:

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	Racing Market 360° Stakeholder Feedback	
		General
		F1
		NASCAR
		WEC
		INDYCAR
		Formula-E
		DTM/GT
		Rally Sport
No	Statement	
1	NASCAR very clearly believes that part of its success is its "roots" based technology. It is ironic that the engine gives significant brand identity despite its lack of relevancy to the engine on the street	
2	New kind of efficient combustion	
3	Turn-key projects	
4	We race in NASCAR!! There have been some very vague discussions about adding green technology but the current NASCAR management team are very aware of the massive investment in F1 due to the hybrid rules and the relative lack of public awareness/marketing of this technological achievement	
5	Next Step after full car testing?? => multiple cars? Multiple component dynos linked together? Multiple car dynos linked?	
6	Overall money will not increase	
7	WEC (LMP1) wird eine R&D Kostenexplosion erleben und diese wird durch die Möglichkeiten von "Road to Rig" getrieben. Ich bin mir sicher das in elektrifizierten Antriebssträngen noch sehr viel Potenzial steckt um Rundenzeiten zu verkürzen und Kraftstoff zu sparen. Porsche hat den Weg dorthin eröffnet und die anderen müssen nachlegen. Der erste Schritt wird sein dass die "alte Garde" versucht aufzuschließen mit den klassischen Entwicklungen von Antriebsstrangkomponenten (ICE, GBX, E-MOT, Inverter ...). Doch ich denke dass die Effizienz aus der Betriebsstrategie und der Nutzung der thermischen Verluste kommen wird	
8	Economy crises; Indicators: Car sales, bank situations, stock, etc.	
9	Dieselgate: If other manufacturers get themselves caught up in this affair it could have an impact on their Racing involvement (Mercedes, Renault, Toyota)	
10	Dieselgate: Early recovery of VW could bring their potential F1 involvement (Audi?) back on track	
11	Managing board supports / likes Racing or does not, Indicators: When board members get changed	
12	Toyota is in a strong cash position and will continue to look to invest in technology that can improve its top level motorsports programs especially technology that maybe on the leading edge	
13	Economic situation of the company (OEM) has significant impact on involvment decision despite the marketing factor	
14	Gehts dem Unternehmen gut, gehts dem Motorsport gut	
15	Stop of F1 involvement in order to reduce commercial cost	
16	Formula-E: Increasing success and popularity of series could attract new OEM's to come in (BMW i-Brand?)	

Figure 13: Structured stakeholder feedback

3.3 Market Trend Analysis

In the Market Trend Analysis, the individual stakeholder feedbacks are then clustered into common trends where different statements have the same or very similar content. These trends are then further categorized in the following main streams that define the main areas leading to market changes:

1. Manufacturer Policies: Change in internal policies that might have an impact on the motorsports involvement of OEMs
2. Marketing/Business Relevance: Relevance of a race series as marketing or technology platform

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3. Change in Markets/Players: Establishment of new race series, involvement or withdrawal of OEMs in existing race series
4. Public Restrictions/Influence: Political, environmental or social factors that have an influence on motorsports
5. Regulations & Technologies: Change of commercial/sporting/technical regulations of existing race series
6. Shift in Spectator Interest: Increasing or decreasing spectator interest in motorsports

The individual trends are rated regarding the probability of occurrence and their severity of impact on AVL:

Probability: (1) Low, (2) Medium, (3) High

Severity: (1) Low, (2) Medium, (3) High

These ratings are input for the prioritization of the derived actions out of the Market Trend Analysis.

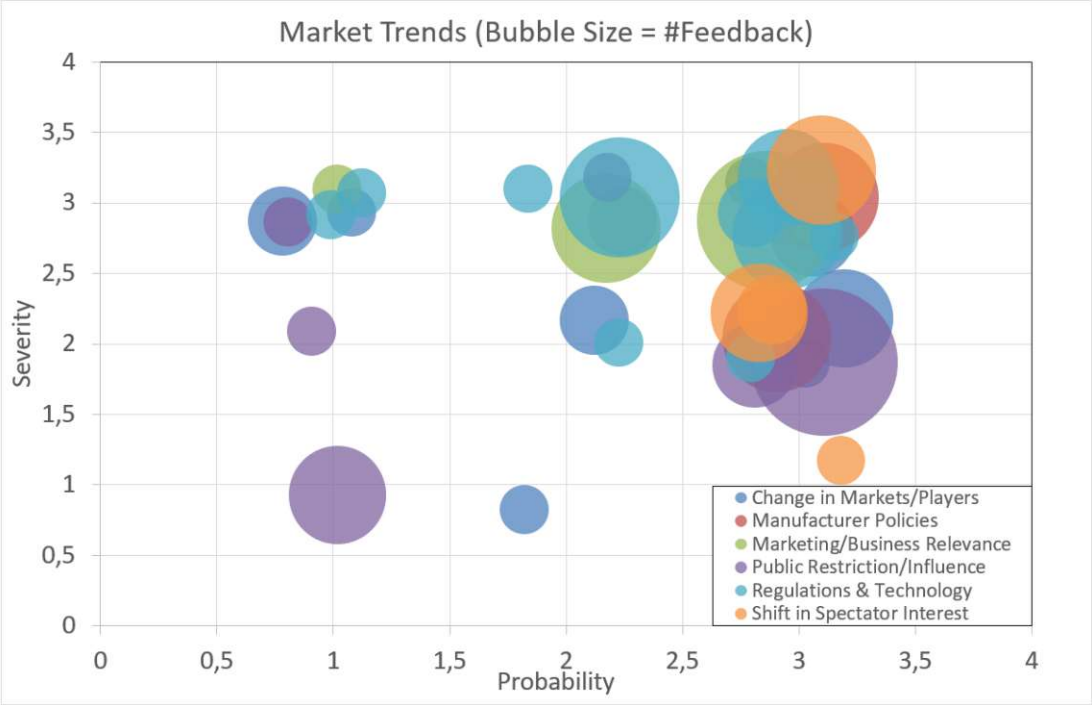

Figure 14: Market trends rated in probability and severity

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To have the possibility to monitor the individual trends, which is the basis for being able to react accordingly, indicators for each trend are defined. These indicators are utilized for a semi-annual review of the trends where the probabilities are adjusted accordingly.

Additionally, for each trend dedicated actions/reactions are determined which are required to adjust AVL RACING's activities in Business Development, Sales, Research & Development, Training and Marketing.

No	Stream	Stream ID	Trend	Indicators	Probability	Severity	Actions/Reactions
1	Change in Markets/Players	3	Electric/Hybrid Racing/Street Courses	- FIA sanctioned series - IMSA - E-MotoGP - NASCAR - IndyCar - sanctioning bodies trying to attract new manufacturers	3	3	(1) electrify racing product portfolio (2) insource know-how
2	Change in Markets/Players	3	Rising interest in emerging markets for motorsports	- more races in China - more export of passenger cars - more domestic race series - China, India, Thailand, Mexico, South America, Vietnam, Russia, Africa	2	3	(3) Fact Finding/ Identifying potentials
3	Change in Markets/Players	3	Autonomous, RoboRace, Virtual Pace Cars	- more than one existing roborace car - autonomous safety car, autonomous pit, etc.	2	1	(3) (4) Finding out AVL capabilities and strategy
4	Change in Markets/Players	3	New ownership of NASCAR	- Brian France go to jail	3	2	(5) Monitor NASCAR Situation
6	Change in Markets/Players	3	New F1 PU supplier	X76 project Toyota depending on HONDA success in F1	3	3	
7	Change in Markets/Players	3	New IndyCar PU supplier	regulation changes necessary	1	3	(6) Monitor IndyCar Situation

Figure 15: Market trend definition with indicators and according actions

3.4 Scenario Building

To evaluate the business impact of the market trends over the evaluated time period individual scenarios are built. The business impact is measured in order intake. Out of each market trend an individual scenario is built that is again rated in probability in a scale from 0 to a 100% with 5 % increments possible. Compared to the rather coarse rating in the Market Trend Analysis process this finer rating enables a more precise evaluation of the business impact. Out of the probability the variance for a binominal event is calculated:

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$$\sigma^2 scenario = Pscenario \times (1 - Pscenario) \quad (1)$$

with

$\sigma^2 scenario \ldots Variance\ of\ individual\ scenario$

$Pscenario \ldots Probability\ of\ individual\ scenario$

The order intake for the following areas is evaluated:

Test System Lines: Business opportunities for the sale of new test systems or the adaptations of existing test systems. Can also be a negative number in case of OEM withdrawals from race series or restricted technical regulations.

Service and Support: Business related to support activities for the installed base of test systems, spare parts, maintenance, repairs and trainings

Standalone Instruments & Tools: Business for the sale of standalone instruments and tools outside of complete test systems.

The overall annual order intake has been calculated by the individual annual order intakes of the above listed areas.

	Scenario	ICE efficiency increase outside F1, WEC, F-E; fuel limitations; emission limitation; pre-chamber				
	Description	Regulations & Technology				
	Probability	80%				
	Variance	16%				
		2018 [k€]	**2019 [k€]**	**2020 [k€]**	**2021 [k€]**	**2022 [k€]**
	ITS	0	0	2.550	765	765
SBU	**Portfolio**	**2018 [k€]**	**2019 [k€]**	**2020 [k€]**	**2021 [k€]**	**2022 [k€]**
ITS	N Chassis Testing					
ITS	N Engine Testing			2000		
ITS	N ERS, Hybrid, Electric Testing			500	750	750
ITS	N Powertrain, MultiConfig, Transmission Testing					
ITS	S CARE					
ITS	S Spares, Service & Training			50	15	15
ITS	M Instruments					
ITS	X Calibration & Data Management					

Figure 16: Scenario definition

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To compose a forecasted annual order intake all the individual scenarios, the order intake numbers are added up and weighted with the individual scenario probabilities to get the expected value:

$$OIannual = \sum_{i=1}^{n} OIscenario_i \times Pscenario_i \quad (2)$$

with

$OIannual \ldots annual\ forcasted\ order\ intake$

$OIscenario \ldots Order\ intake\ of\ individual\ scenario$

$Pscenario \ldots Probability\ of\ individual\ scenario$

To also account for variance in annual order intake, the individual scenario variances are also considered to get the 95% confidence interval:

$$OIannual_{lo} = \sum_{i=1}^{n} OIscenario(i) \times Pscenario(i) - OIscenario(i) \times \sigma^2 scenario(i) \quad (3)$$

$$OIannual_{hi} = \sum_{i=1}^{n} OIscenario(i) \times Pscenario(i) + OIscenario(i) \times \sigma^2 scenario(i) \quad (4)$$

with

$OIannual_{lo} \ldots annual\ forcasted\ order\ intake\ low$

$OIannual_{hi} \ldots annual\ forecasted\ order\ intake\ high$

$\sigma^2 scenario \ldots variance\ of\ individual\ scenario$

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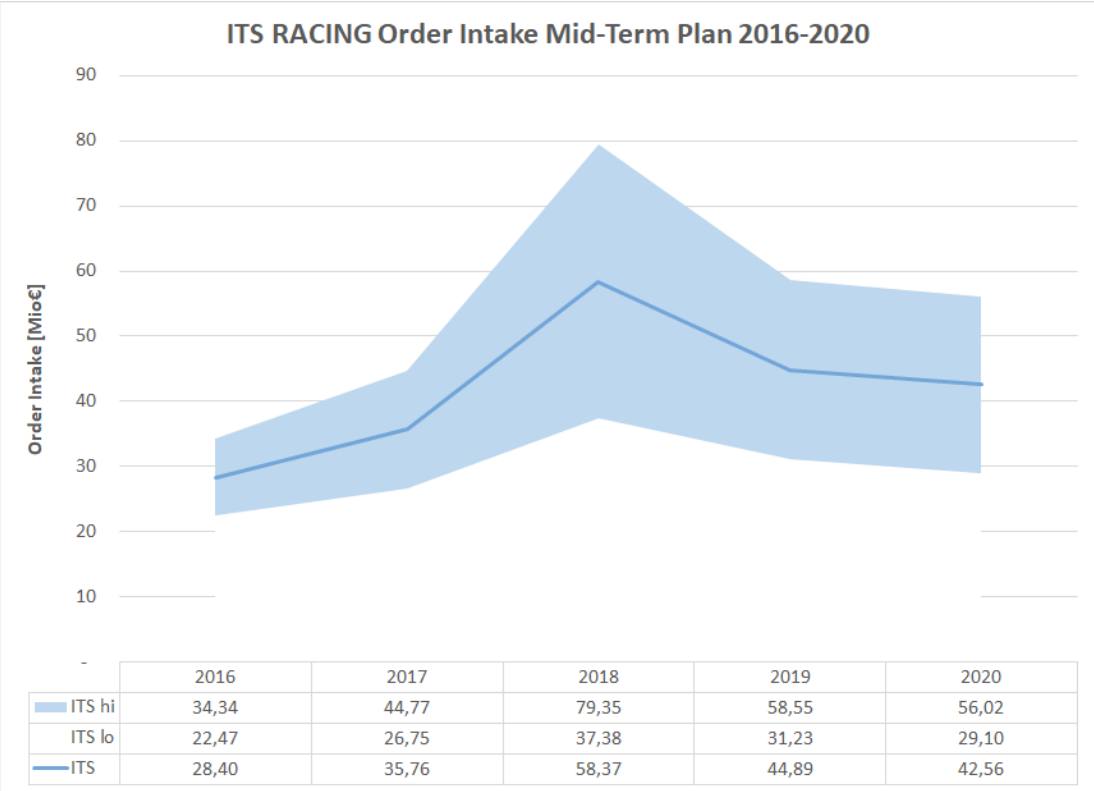

Figure 17: Five-year order intake forecast

3.5 Strategy Definition

In the final step of Strategy Definition, the derived actions out of the Market Trend Analysis are categorized into specific detailed action items. This categorization is done according to the following parameters:

- *Action:* Name of action defined in the Market Trend Analysis
- *Existing/Adapted/New:* Defines whether an action is already existing, an existing action needs to be adapted or a new action is required
- *Details:* Specific detailed content of the action
- *RASI:* RASI (Responsible/Accountable/Support/Informed) definition of the AVL RACING group
- *Responsibility:* Definition of responsible person for the action
- *Target:* Target date for action completion
- *Priority:* Priority of action (1: High, 2: Medium, 3: Low)

The priority of the individual actions is calculated out of the probability and severity defined in the Market Trend Analysis:

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$$Priority = |3{,}5 - \frac{P \times Severity}{2}| \quad (5)$$

with

$Priority \ldots Priority\ of\ individual\ action$

$P \ldots Probability\ of\ individual\ action$

$Severity \ldots Severity\ of\ individual\ action$

In order to utilize the available resources most efficiently the focus is on actions with Priority 1, followed by Priority 2 and Priority 3.

3.6 Monitoring

Based on the actual developments in the global racing market and the set indicators of the Market Trend Analysis, the probabilities of the Market Trends and Scenarios are updated and adjusted in a biannual review within the same panel of participants from AVL RACING. These updates then also correct the priorities of the individual actions which results in a confirmation or adjustment of the strategic initiatives.

3.7 Review and Evaluation of Previous Scenario Planning

The scenario planning process was introduced in the AVL RACING group in 2014 and has been performed on a biennial basis. To date three scenario planning processes have taken place performed in the years 2014, 2016 and 2018.

The feedback rate on the questionnaires sent to various internal and external stakeholders showed a general stable feedback rate over the different years, averaging at 25%.

Year	# Questionnaires sent	# Feedback received	% received
2014	82	21	26%
2016	85	19	22%
2018	72	19	26%
		Average	25%

Figure 18: Questionnaires feedback statistics

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In order to review the individual scenarios between forecast vs. actual, the scenarios are clustered based on their probability into five probability ranges:

1: 0%..20%

2: >20%..40%

3: >40%..60%

4: >60%..80%

5: >80%..100%

Each scenario then was classified whether it had occurred or not. Based on this classification the percentage of occurred scenarios out of the total scenarios of each probability range was calculated:

$$Occurrence = \frac{True}{Total} \times 100 \tag{6}$$

with

$True \ldots Number\ of\ individual\ scenarios\ that\ occurred$

$Total \ldots Number\ of\ total\ scenarios$

The percentage of the occurrence was then compared to a reference occurrence according to the mean of the individual probability range:

Probability range	Mean occurrence
0%..20%	10%
>20%..40%	30%
>40%..60%	50%
>60%..80%	70%
>80%..100%	90%

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The following diagrams illustrate the retrospective scenario analysis regarding their estimated probability and compared to whether they occurred.

The individual bars in the diagrams are labeled:

scenarios true (total # scenarios in probability range) % (true/total)

Example:

4 (10), 40%

In 2014, based on the stakeholder feedback a total of 29 scenarios have been created.

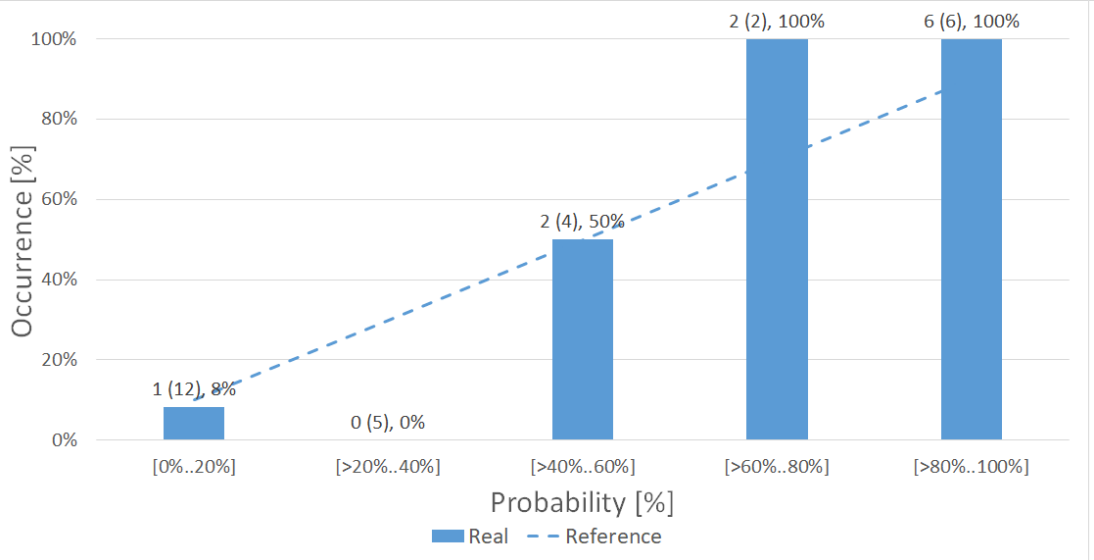

Figure 19: Scenario hit rate in 2014

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In 2016, based on the stakeholder feedback a total of 47 scenarios have been created.

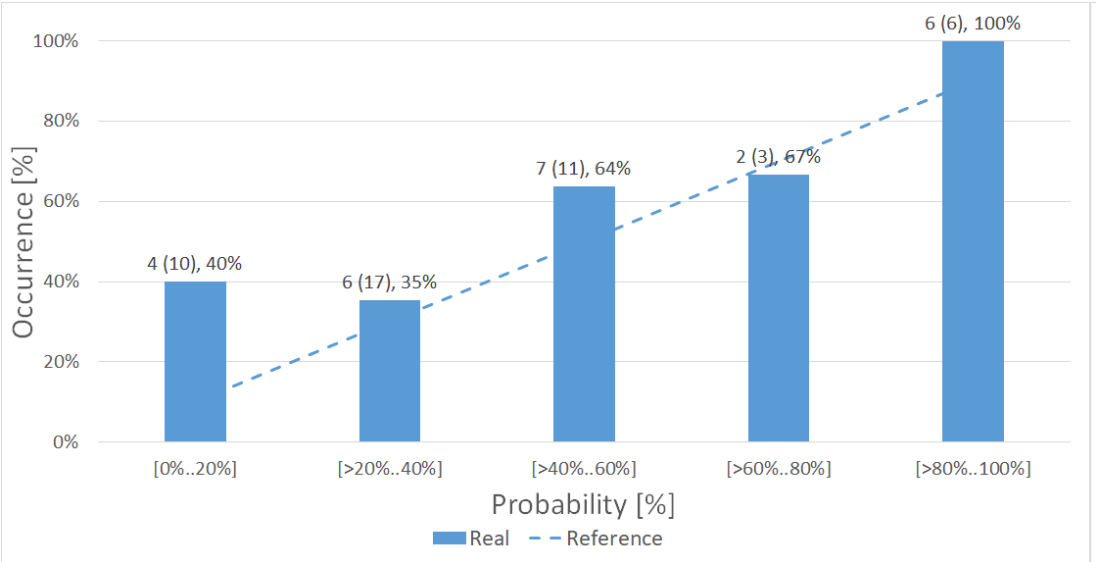

Figure 20: Scenario hit rate in 2016

In 2018, based on the stakeholder feedback a total of 33 scenarios have been created.

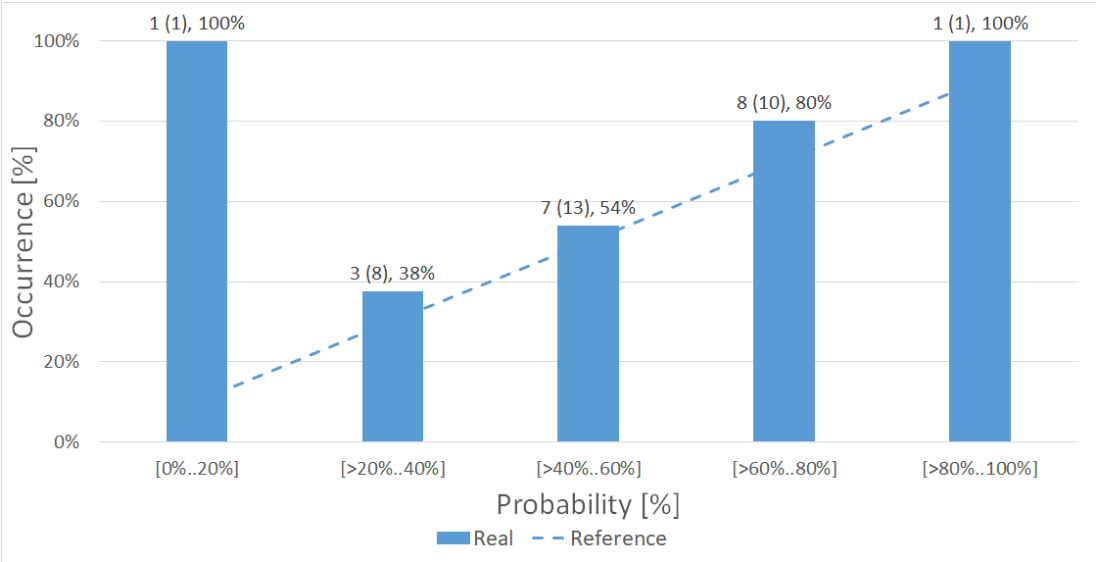

Figure 21: Scenario hit rate in 2018

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The development of the accuracy of the scenario probability estimation shows a steady increase in subsequent scenario planning processes.

In the review of the order intake forecast, the actual order intake from the timeframe 2015 to 2020 is compared to the forecasts generated in the individual scenario planning processes. To evaluate the accuracy the deviation between forecast and actual is calculated:

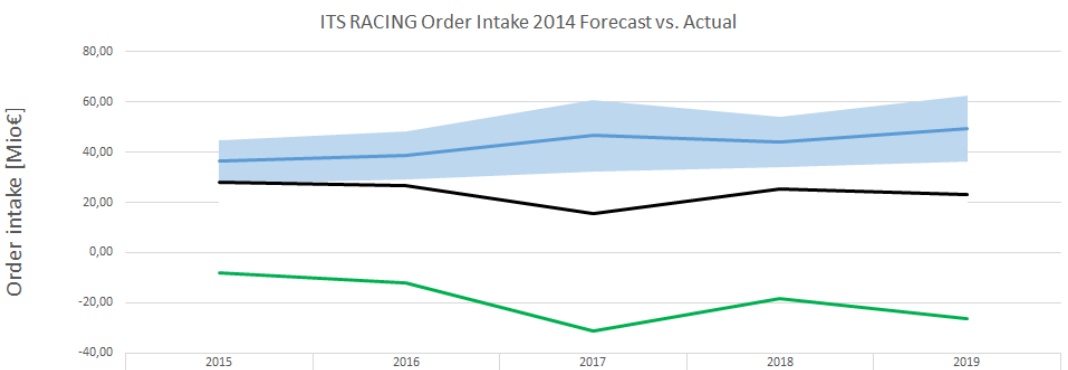
$$Deviation = OI_{actual} - OI_{forecast} \tag{7}$$

with

OI_{actual} ... $Actual\ order\ intake$

$OI_{forecast}$ ... $Forecasted\ order\ intake\ of\ scenario\ planning\ process$

In 2014 an order intake forecast was generated with a 95% confidence level based on the scenario variance for the following five years. A comparison to the actual order intake (2015 – 2019) shows the following deviation:



	2015	2016	2017	2018	2019
2014_High	44,90	48,30	60,70	54,00	62,60
2014_low	27,60	29,10	32,40	34,00	36,30
2014_Forecast	36,30	38,70	46,60	44,00	49,50
ITS RACING	28,20	26,50	15,51	25,53	23,17
Deviation	-8,10	-12,20	-31,09	-18,47	-26,33

Figure 22: 2014 order intake forecast vs. actual

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In 2016 an order intake forecast was generated with a 95% confidence level based on the scenario variance for the following five years. A comparison to the actual order intake (2017 – 2020) shows the following deviation:

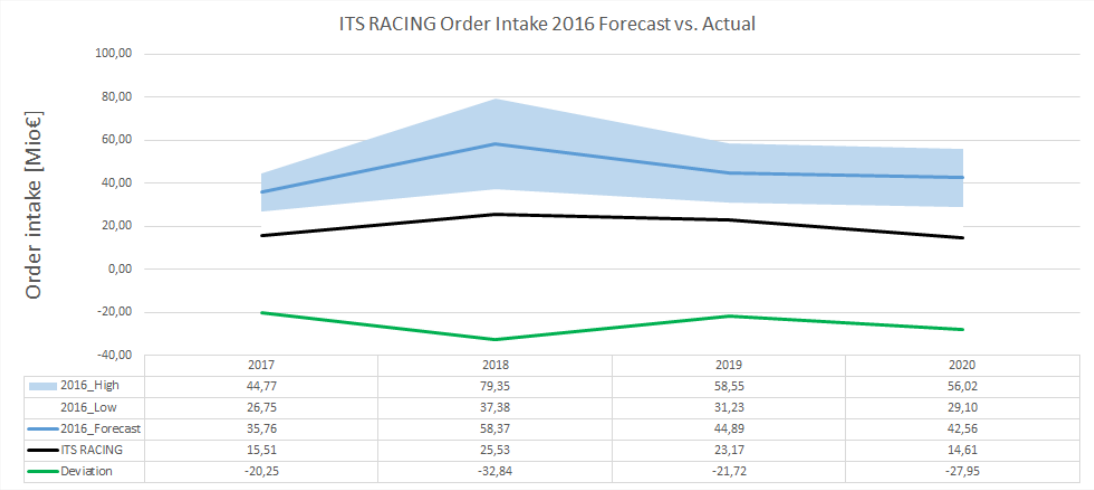

Figure 23: 2016 order intake forecast vs. actual

In 2018 an order intake forecast was generated with a 95% confidence level based on the scenario variance for the following five years. A comparison to the actual order intake (2019 – 2020) shows the following deviation:

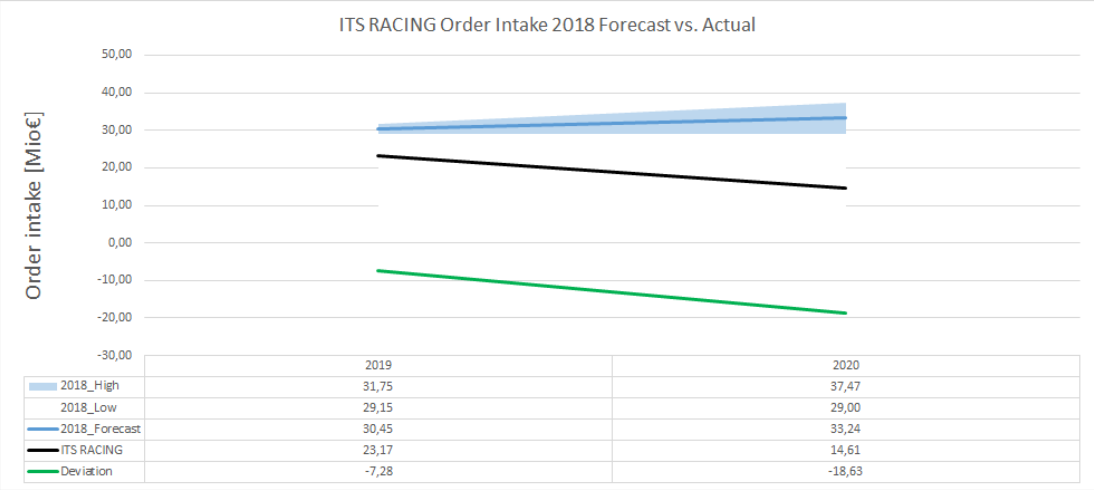

Figure 24: 2018 order intake forecast vs. actual

The comparison of the individual order intake forecasts with the actual order intake shows a constant forecast overestimation which is well outside of the 95% confidence

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level. This inaccuracy does make this forecasting method not suitable for proper midterm planning.

3.8 Chapter Summary

The chapter outlined the individual steps of the scenario planning process as currently implemented in the AVL RACING business segment. A review of planning processes performed to date revealed a steady stakeholder feedback rate with input that generated solid scenarios for the development of the global motorsports market in the following five years. While the occurrence of the individual scenarios based on the estimated probability showed satisfactory accuracy to derive strategic actions, the resulting order intake forecast lacked said accuracy for proper midterm planning.

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4 BUSINESS FORECAST

As already outlined in chapter 2.7, the motorsports market is subject to regulation changes in order to implement new technologies to make it an attractive platform for OEMs. Another objective is keeping the cost to compete in control to make it economically feasible for teams to participate as well as to make sure there is a level of parity amongst the race teams to keep it interesting for the consuming audience. These different requirements that dictate the technical and sporting regulations for the individual race series, highly depend on the state of technology, economic situation of interested and participating OEMs and teams and changes in spectators' interest. When the regulations and the economic situation is stable a business forecast is not difficult to generate. But sudden regulations changes can significantly impact the required activities and can also result in the entry or withdrawal of OEMs or teams. General global or regional events that have an impact on the economy are also influencing available budgets for motorsports activities. These rather unpredictable influencing factors can be treated as impacts into a rather predictable base trend. Therefore, the trend-impact analysis as a forecasting method presents itself as a proper tool to address this challenge.

4.1 Trend-Impact Analysis

The trend-impact analysis (TIA) is a hybrid forecasting method that combines traditional quantitative forecasting based historical data with qualitative methods that consider for example experts' opinion on future events (Agami et al., 2008).

These future events are rated in terms of impact shape, impact magnitude, impact duration and remaining steady impact. In addition, there is a rating of the probability of occurrence.

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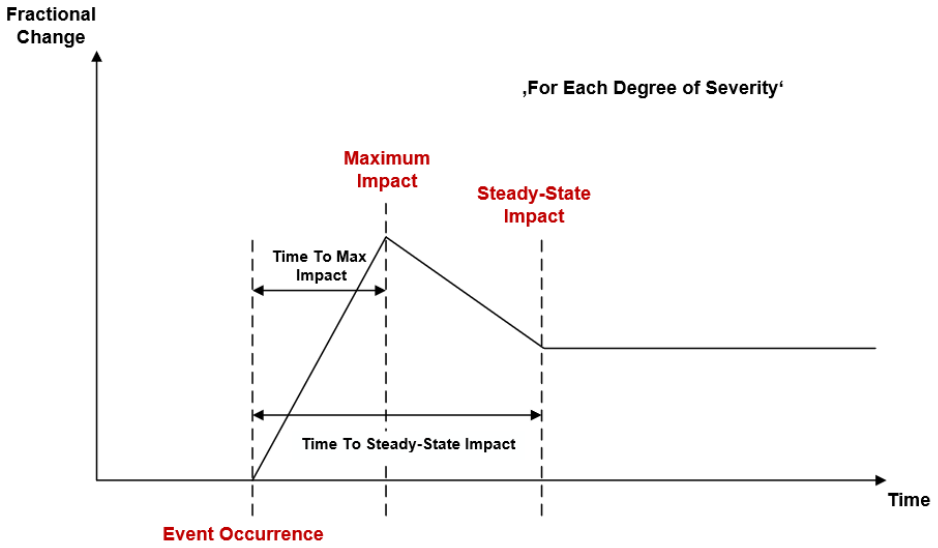

Figure 25: Graphical example of future event (Agami et al., 2008)

These impacts are then added to an event-free forecast based on historical data. The result is a joint forecast that incorporates the benefits of the quantitative history as well as the effects of potential future events.

For the AVL RACING business forecasting both attributes are beneficial. The base business resulting from the global installed base of test systems is rather stable and can be utilized for the quantitative basis trend forecast. The volatility in the market coming from the economy, state of technology, regulation changes and spectator interest are already captured in the scenario building process as described in chapter 3.4 but they are lacking the proper definition as shown in Figure 23.

4.2 AVL RACING Market Segmentation

Based on business data as well as the installed base from 2012 – 2020 the AVL RACING test systems market can be segmented into the following categories:

- Formula 1 (F1)
- World Endurance Championship (WEC)
- Rally (including the World Rally Championship and World Rallycross)
- NASCAR
- IndyCar
- MotoGP
- GT (including DTM, SuperGT, GTLM and WTCC)
- Formula E
- Others (annual occasional projects outside of major race series)

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Existing customers participating in the above-mentioned race series are categorized as engine suppliers (including internal combustion engines and electric motors) or chassis suppliers (including the drivetrain consisting of a gearbox, differential, axles and wheel hub).

The overview below shows the AVL RACING test systems customer base between 2012. Highlighted in grey is the timeline the teams competed in the individual race series and utilized AVL RACING test systems.

Series	Team	Category	2012	2013	2014	2015	2016	2017	2018	2019	2020
F1	Ferrari	Engine									
	Mercedes	Engine									
	Honda	Engine									
	Renault	Engine									
	Ferrari	Chassis									
	Mercedes	Chassis									
	Red Bull Racing	Chassis									
	Porsche	Engine									
WEC	Audi	Engine									
	Toyota	Engine									
Rally	Hyundai	Engine									
	Ford/M-Sport	Engine									
	PSA/Citroen	Engine									
	VW	Engine									
	Toyota	Engine									
NASCAR	Toyota	Engine									
	Roush Yates	Engine									
	HMS	Engine									
	ECRE	Engine									
	JoeGibbs	Chassis									
	SHR	Chassis									
	GM Racing	Engine									
	Ford	Engine									
	Penske	Engine									
IndyCar	HPD	Engine									
	Ilmor	Engine									
MotoGP	Honda	Engine									
	Ducati	Engine									
	KTM	Engine									
GT	BMW	Engine									
	Audi	Engine									
	Toyota	Engine									
	Honda	Engine									
	Cyan	Engine									
	NISMO	Engine									
Formula E	Audi	Engine									
	Mercedes	Engine									
Others		Engine									

Figure 26: AVL RACING global installed base segmentation

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The annual business related to the individual categories highlights the different magnitudes of the share of these markets. About 90% of the annual order intake is related to F1, WEC, NASCAR, GT, IndyCar and MotoGP. Therefore, the focus in forecasting is put on these markets.

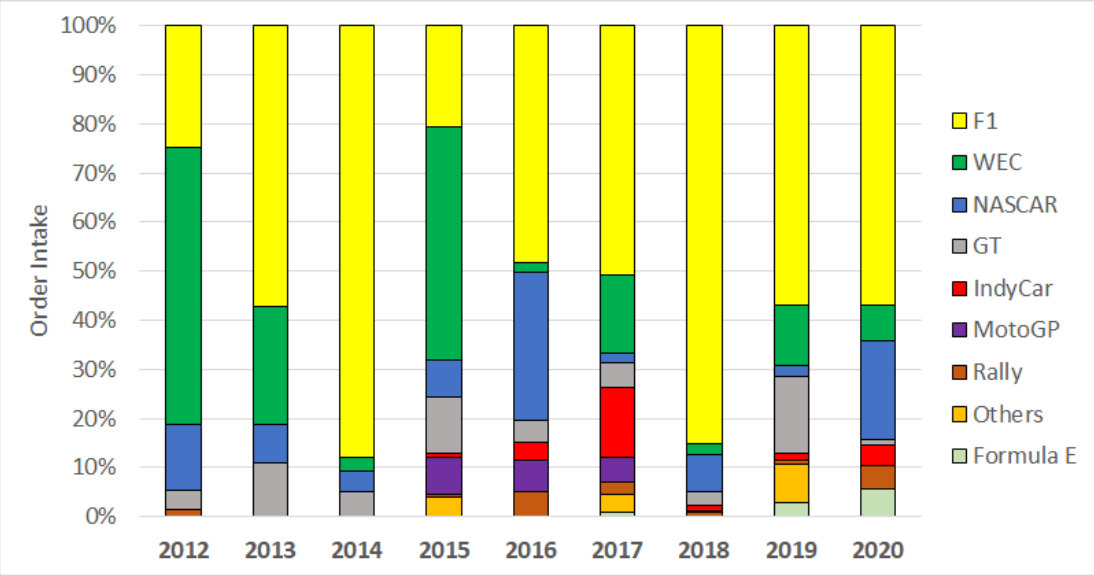

Figure 27: Annual order intake shares of race series

4.3 Trend and Event Impact Definition

To implement the trend-impact analysis as a forecasting method into the AVL RACING scenario planning process a detailed assessment of accurate historical business data is required. For this assessment the data from the timeframe 2012 to 2020 was selected. In 2012, the brand “AVL RACING” as a dedicated group within the AVL List GmbH was created and introduced to the global motorsports market. This dataset was structured according to the categories shown in Figure 24 and is used as input for the trend and event impact definition. The annual business numbers have been categorized into base business, business related to the entry of a new team into a series and business related to major regulation changes.

As event-free trend all annual business related to the global installed test systems base is defined. This is the annual base business not related to major regulation changes or the entry or exit of a manufacturer or team. In a first step the annual base business per team and category for each race series is calculated:

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$$Base = \frac{\sum_{i=2012}^{2020} Annual\ base\ OI(i)}{\sum_{i=2012}^{2020} Teams(i)} \quad (8)$$

with

$Annual\ base\ OI \ldots\ annual\ base\ order\ intake\ per\ series, team\ and\ category$

$Teams \ldots\ annual\ \ number\ of\ teams\ per\ series\ and\ category$

For easier reference the result is rounded to the nearest 0.25m € step.

The annual event-free base business which is used as the trend for the trend-impact analysis is the sum of the annual base business of the individual series and categories and the annual number of competing teams for the year the trend-impact analysis is performed:

$$Trend = \sum Base \times Teams \quad (9)$$

with

$Base \ldots annual\ base\ order\ intake\ per\ series, team\ and\ category$

$Teams \ldots\ annual\ number\ of\ teams\ per\ series\ and\ category$

For the possible future events that have a significant impact on the business, the following events for each race series and category have been identified:

- *Team entry (Entry):* annual order intake related to the entry of a new team
- *Team withdrawal (Exit):* annual order intake drop related to the withdrawal of a team
- *Major regulation change (Change):* annual order intake related to a major regulation change
- *Shift (Shift):* annual order intake shift related to a trend rather than a single event
- *Competition (Comp):* annual order intake impact due to growing competition
- *Economy global (Eco_glob):* annual order intake impact due to a changing global economic situation
- *Economy region (Eco_reg):* annual order intake impact due to a changing regional economic situation

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Entry: The entry of a new team into a series is typically related to required investments in test systems that result in a single increase in annual order intake.

- Impact duration: 1 year
- Steady state impact: increase in base business in the following years
- Magnitude calculation:

$$Entry = \frac{\sum_{i=2012}^{2020} Annual\ entry\ OI(i)}{\sum_{i=2012}^{2020} Entry\ teams(i)} \tag{10}$$

with

$Annual\ entry\ OI$ … $annual\ entry\ order\ intake\ per\ series\ and\ category$

$Entry\ teams$ … $annual\ \ number\ of\ entering\ teams\ per\ series\ and\ category$

For easier reference the result is rounded to the nearest 0.25m € step.

Exit: The withdrawal of a team from a series is typically related to a decrease in base business because the installed base of test systems is not utilized for this purpose anymore.

- Impact duration: continuous
- Steady state impact: decrease in base business in the following years
- Magnitude calculation:

$$Exit = Base \times -1 \tag{11}$$

with

$Base$ … $annual\ base\ order\ intake\ per\ series, team\ and\ category$

Change: Major regulations changes in a series typically require modifications or additions to the installed base of test systems that result in a single increase in annual order intake. This event can be also applied negatively (order intake) if the regulation change is restricting investments.

- Impact duration: 1 year
- Steady state impact: none
- Magnitude calculation:

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$$Change = \frac{\sum_{i=2012}^{2020} Annual\ change\ OI(i)}{\sum_{i=2012}^{2020} Changes(i) \times Teams(i)} \quad (12)$$

with

$Annual\ change\ OI$ … $annual\ regulations\ change\ order\ intake\ per\ series\ and\ category$

$Changes$ … $annual\ \ number\ of\ regulation\ changes\ per\ series\ and\ category$

For easier reference the result is rounded to the nearest 0.25m € step.

Shift: An event that is causing a continuous shift in the base business. This can be a positive or negative shift. The assumption is made that the magnitude of the shift is the same as the magnitude for a regulation change for one team.

- Impact duration: continuous
- Steady state impact: change in base business in the following years
- Magnitude: 1x Change

$$Shift = 1 \times Change \quad (13)$$

with

$Change$ … $annual\ change\ order\ intake\ per\ series, team\ and\ category$

Comp: Impact on annual base business due to stronger competition in the test systems market. The assumption is made that the impact is a 10% decrease of the base business.

- Impact duration: continuous
- Steady state impact: change in base business in the following years
- Magnitude calculation:

$$Comp = Trend \times -0{,}1 \quad (14)$$

with

$Trend$ … $annual\ event\ free\ base\ business$

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Eco_glob: Impact to base business due to negative changes in the global economic situation. Based on historical data this event is defined as a 25% decrease on the base business. The duration for this event is two years.

- Impact duration: 2 years
- Steady state impact: none
- Magnitude calculation:

$$Eco_glob = Trend \times -0{,}25 \tag{15}$$

with

$Trend \ldots annual\ event\ free\ base\ business$

Eco_reg: Impact to base business due to negative changes in the regional economic situation. Based on the AVL RACING global installed base the regions Europe, United Kingdom, Japan and the United States are relevant. For simplification an even split of the annual business to the four regions is assumed.

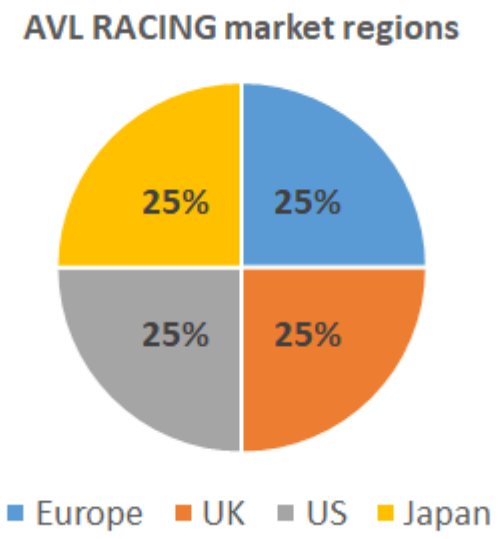

Figure 28: AVL RACING market regions

Based on historical data this event is defined as a 25% decrease on the regional base business. The duration for this event is two years.

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- Impact Duration: 2 years
- Steady state impact: none
- Magnitude calculation:

$$Eco_reg = \frac{Trend}{4} \times -0{,}25 \tag{16}$$

with

$Trend \ldots annual\ event\ free\ base\ business$

Based on these defined events and the historical data the following table has been calculated that shows the magnitudes of the events for the individual series and categories as well as the trends for the years 2014, 2016 and 2018 in which the scenario planning process has been performed in the past:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		**Series**	**F1**		**WEC**	**Rally**	**NASCAR**		**IndyCar**	**MotoGP**	**GT**	**Formula E**	**Others**			
2		**Category**	**Engine**	**Chassis**	**Engine**	**Engine**	**Engine**	**Chassis**	**Engine**	**Engine**	**Engine**	**Engine**	**Engine**			
3	**Description**	**Impact**													**All numbers in**	
4	Base business	Base	1,00	0,25	1,00	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,50			**Mio€**
5	Team entry	Entry	20,00	5,00	5,00	1,50	5,00	0,00	5,00	1,50	2,00	1,00	1,00			
6	Team withdrawal	Exit	-1,00	-0,25	-1,00	-0,25	-0,25	-0,25	-0,25	-0,25	-0,25	-0,25	-0,50			
7	Major regulation change	Change +	2,00	2,00	2,00	1,00	1,50	1,50	1,00	1,00	1,00	1,00	0,50			
8	Major regulation change	Change -	-2,00	-2,00	-2,00	-1,00	-1,50	-1,50	-1,00	-1,00	-1,00	-1,00	-0,50			
9	Shift positive	Shift +	2,00	2,00	2,00	1,00	1,50	1,50	1,00	1,00	1,00	1,00	0,50			
10	Shift negative	Shift -	-2,00	-2,00	-2,00	-1,00	-1,50	-1,50	-1,00	-1,00	-1,00	-1,00	-0,50			
11	Competition	Comp												-1,225	-1,275	-1,325
12	Economy global	Eco_glob												-3,063	-3,188	-3,313
13	Economy region	Eco_reg												-1,531	-1,594	-1,656
14																
15	Teams (Installed base)		4	3	2	4	6	1	2	2	5	0	1	**2014**		
16		Trend	4	0,75	2	1	1,5	0,25	0,5	0,5	1,25	0	0,5	12,25		
17		Change_t	8	6	4	4	9	1,5	2	2	5	0	0,5			
18	Teams (Installed base)		4	3	2	4	6	1	2	3	6	0	1		**2016**	
19		Trend	4	0,75	2	1	1,5	0,25	0,5	0,75	1,5	0	0,5		12,75	
20		Change_t	8	6	4	4	9	1,5	2	3	6	0	0,5			
21	Teams (Installed base)		5	3	1	5	6	1	2	3	6	1	1			**2018**
22		Trend	5	0,75	1	1,25	1,5	0,25	0,5	0,75	1,5	0,25	0,5			13,25
23		Change	10	6	2	5	9	1,5	2	3	6	1	0,5			

Figure 29: Event definition table

4.4 AVL RACING Business Forecast with Trend-Impact Analysis

To generate the AVL RACING business forecast for the following five years the existing business estimations in defined scenarios from the previous scenario planning processes are replaced by the events defined in Figure 27. The already existing probability and variance ratings are used again to calculate the order intake numbers. Previous scenarios that are related to specific customer projects have been classified as being part of the base business, since those are not directly related to any of the defined events.

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In addition to the probability and variance, each individual scenario is extended with the following attributes:

- *Series:* applicable race series (row 1 in Figure 27)
- *Category:* applicable category (row 2 in Figure 27)
- *Impact:* applicable event (column B in figure 27)
- *Year:* year of impact of event

No.	Scenario	Probability	Variance	Series	Category	Impact	Year
1	New F1 Engine Manufacturer in 2020	35%	23%	F1	Engine	Entry	2018
2	DynoPro/BobCat	100%	0%	Others	Engine	Base	2017
3	F1 Business	100%	0%	F1	Engine	Base	2017
4	V8 Supercars Engine business	30%	21%	GT	Engine	Base	2019
5	Haas formula developing full F1 car by 2020	30%	21%	F1	Chassis	Entry	2018
6	New engine supplier in INDYCAR series by 2020	15%	13%	IndyCar	Engine	Entry	2018
7	Hybrid powertrain in INDYCAR series by 2020	25%	19%	IndyCar	Engine	Change +	2018
8	One serious competitor for test system (Customer, K&S, MTS, D2T, etc.)	50%	25%	Others	Engine	Comp	2017
9	Renault F1 testfield	50%	25%	F1	Engine	Base	2017
10	PTE competition increasing	50%	25%	Others	Chassis	Base	2017
11	Global GT hybrid powertrain formula 2019	10%	9%	GT	Engine	Change +	2018
12	New Race Series (i.e. Race without Driver, Fuel-Cell, etc.) by 2020	10%	9%	Others	Engine	Entry	2018
13	New F1 regulation in 2020	50%	25%	F1	Engine	Change +	2018

Figure 30: Scenario definition extended with events

The applicable Trend order intake for each trend-impact analysis is calculated in Figure 27 in cell N15 for 2014, in cell O18 for 2016 and in cell P21 for 2018.

The applicable Competition order intake for each trend-impact analysis is calculated in Figure 27 in cell N11 for 2014, in cell O11 for 2016 and in cell P11 for 2018.

The applicable Economy global order intake for each trend-impact analysis is calculated in Figure 27 in cell N12 for 2014, in cell O12 for 2016 and in cell P12 for 2018.

The applicable Economy region order intake for each trend-impact analysis is calculated in Figure 27 in cell N13 for 2014, in cell O13 for 2016 and in cell P13 for 2018.

Major regulation changes are applicable to all competing teams in each series and category. The annual total change order intake is calculated by the change order intake per team multiplied by the number of competing teams:

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$$Change_t = Change \times Teams \tag{17}$$

with

$Change \ldots annual\ change\ order\ intake\ per\ series, team\ and\ category$

$Teams \ldots\ annual\ number\ of\ teams\ per\ series\ and\ category$

The applicable Change order intake for each trend-impact analysis is calculated in Figure 27 in row 17 for 2014, in row 20 for 2016 and in row 23 for 2018.

The fully computed results for each scenario used in the trend-impact analysis based forecast for the years 2014, 2016 and 2018 can be found in Appendices A, B and C.

4.5 Chapter Summary

With the availability of detailed historic business data combined with a defined market segmentation the required input data for a trend and event definition can be gathered. Combining these trend and event information with the scenarios including the associated probabilities and variance, results in trend-impact analysis that generates a business forecast incorporating the insights from the past into the potential impacts of the future. Having the individual events firmly described and interlinked as selection possibilities to the scenarios also limits the possibility of user input error while generating this forecast. In addition, the event definitions can easily be updated with the availability of new business data in the future and hence further utilized for future forecasting.

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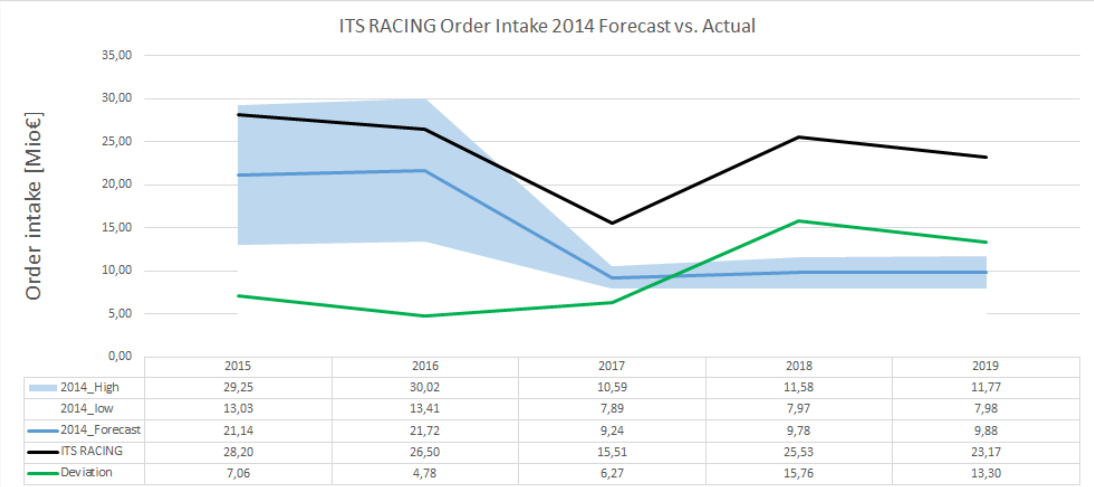
5 TREND-IMPACT FORECAST REVIEW

In order to evaluate the trend-impact analysis based business forecast quality, the generated data with the scenarios from 2014, 2016 and 2018 including a 95% confidence interval (as described in chapter 3.4) are compared to the actual business data from 2015 to 2020.

5.1 2014 Forecast Review

In the 2014 scenario planning process 29 individual scenarios have been generated. The event-free trend has been generated based on the global installed base in 2014 and resulted in an annual stable base business of 12.25m € utilized for the five-year forecast horizon. Detailed forecast results of the individual scenarios can be found in Appendix A.



	2015	2016	2017	2018	2019
2014_High	29,25	30,02	10,59	11,58	11,77
2014_low	13,03	13,41	7,89	7,97	7,98
2014_Forecast	21,14	21,72	9,24	9,78	9,88
ITS RACING	28,20	26,50	15,51	25,53	23,17
Deviation	7,06	4,78	6,27	15,76	13,30

Figure 31: 2014 trend-impact analysis based order intake forecast vs. actual

The results show an improved accuracy compared to the results from the originally generated forecast as shown in chapter 3.7. For the first two years the actual business data are within the 95% confidence interval with an increasing deviation starting in year three.

5.2 2016 Forecast Review

In the 2016 scenario planning process, 47 individual scenarios have been generated. The event-free trend has been generated based on the global installed base in 2016 and resulted in an annual stable base business of 12.75m € utilized for the five-year

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forecast horizon. Detailed forecast results of the individual scenarios can be found in Appendix B.

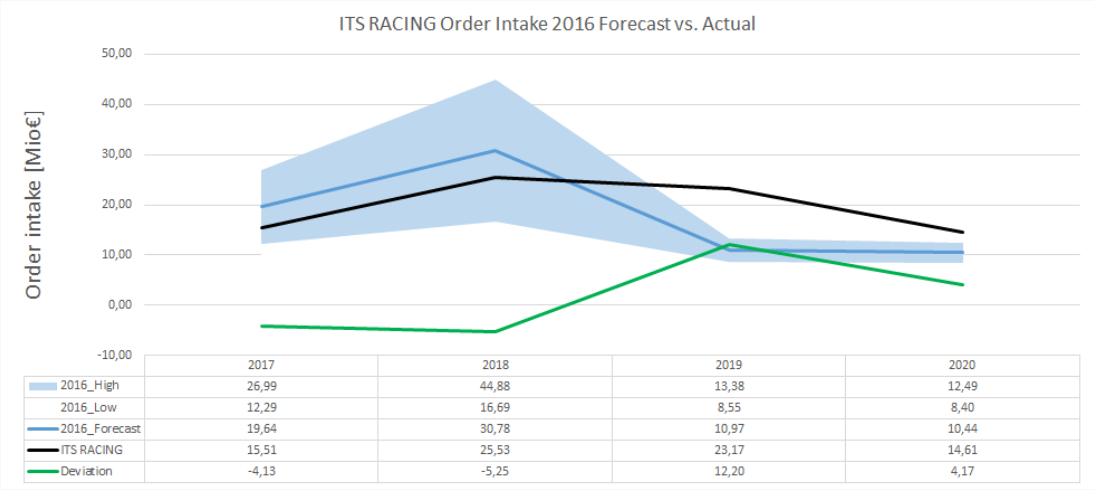

Figure 32: 2016 trend-impact analysis based order intake forecast vs. actual

The results show an improved accuracy compared to the results from the originally generated forecast as shown in chapter 3.7. For the first two years the actual business data are within the 95% confidence interval with an increasing deviation starting in year three.

5.3 2018 Forecast Review

In the 2018 scenario planning process, 33 individual scenarios have been generated. The event free trend has been generated based on the global installed base in 2018 and resulted in an annual stable base business of 13.25m € utilized for the five-year forecast horizon. Detailed forecast results of the individual scenarios can be found in Appendix C.

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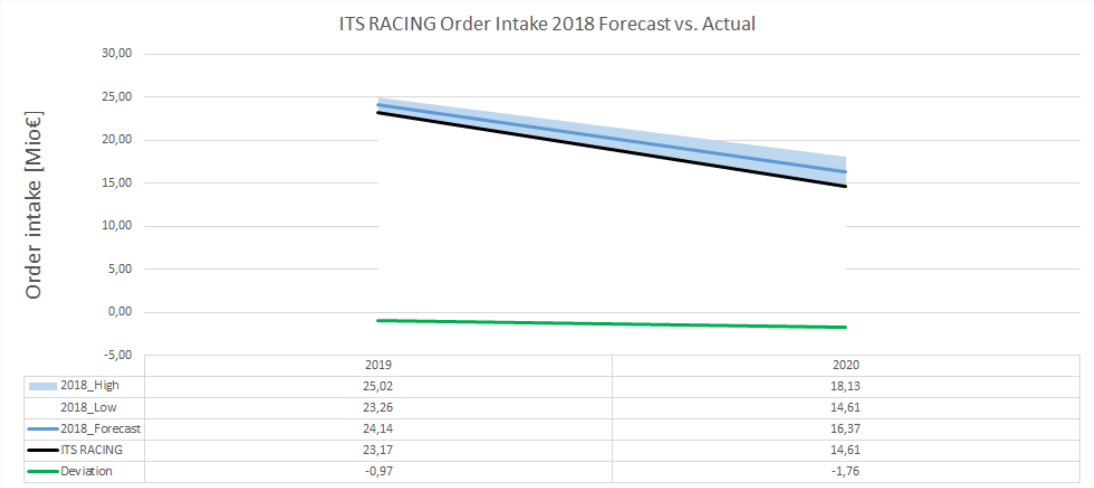

Figure 33: 2018 trend-impact analysis based order intake forecast vs. actual

The results show an improved accuracy compared to the results from the originally generated forecast as shown in chapter 3.7. For the first two years the actual business data are within the 95% confidence interval while a comparison to data past 2020 was not possible.

5.4 Forecast Review Findings

The trend-impact analysis method to generate a business forecast for the AVL RACING test systems market is a vast improvement in the forecast purely from estimations based on experience. The increased forecast deviations starting in the third forecast year result from the fact that for events like major regulation changes or a new entry into a series the necessary investments must be made either one or two years in advance. Therefore, investments in the fourth and fifth year of the forecast horizon would require events that are past that timeframe. In order to generate a five-year forecast required for midterm planning the time horizon for the scenario planning process would need to be extended from the current five years to ten years. Even though the accuracy beyond the five-year horizon will be limited, the forecast will be updated after two years since the scenario planning process is performed on a biannual basis. The shown accuracy for the first two years provides proper data until the next scenario planning process.

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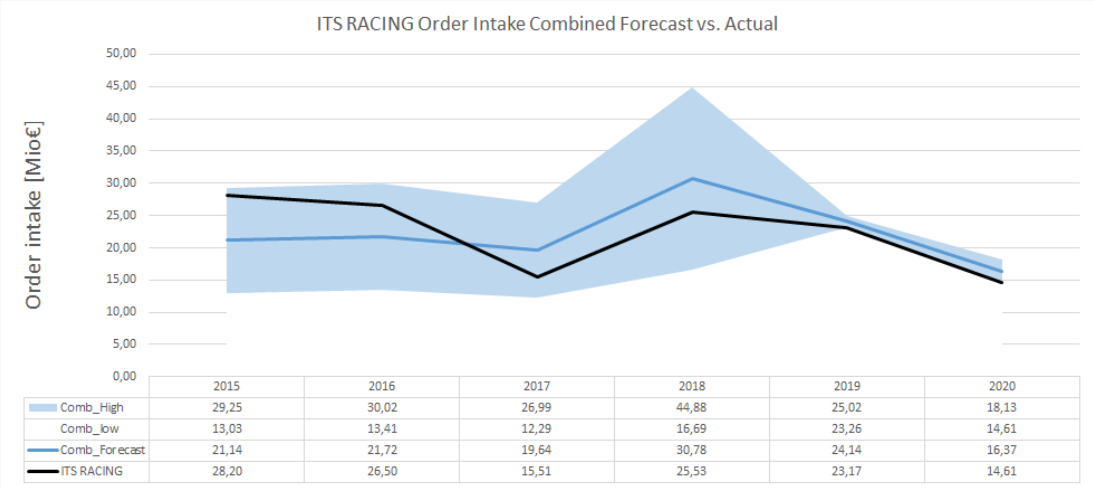

	2015	2016	2017	2018	2019	2020
Comb_High	29,25	30,02	26,99	44,88	25,02	18,13
Comb_low	13,03	13,41	12,29	16,69	23,26	14,61
Comb_Forecast	21,14	21,72	19,64	30,78	24,14	16,37
ITS RACING	28,20	26,50	15,51	25,53	23,17	14,61

Figure 34: Combined trend-impact analysis based order intake forecast vs. actual

5.5 Chapter Summary

The review of the business forecast quality utilizing the trend-analysis method shows a vast improvement in accuracy compared to the purely expert based estimation used in the past. The forecast accuracy for the first two years of the forecast horizon would be sufficient until an update provided by the next scenario planning process, but the recommendation would be to increase the forecast horizon from five to ten years in order to generate a higher quality forecast required for a five year midterm plan.

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6 SUMMARY AND OUTLOOK

6.1 Conclusion

In dynamic market environments, strategic planning is a key element for businesses to navigate through the future. This especially applies to the volatile and unpredictable motorsports market. Strategic planning is an essential tool to forecast requirements for products and services as well as to generate business forecasts to plan required efforts and resources accordingly. Scenario planning offers a variety of methods and tools that can help to predict and to prepare for the uncertainties that lie ahead.

AVL RACING introduced scenario planning based on the HHL-Roland Berger approach (Schwenker / Wulf, 2013) to predict the development of the global test systems market. The approach was adjusted to address and meet the requirements of this specific market. It combines elements of the intuitive logics school and the la prospective school described in chapters 2.4.1 and 2.4.2. Multiple normatively formulated scenarios based on PESTEL input factors are generated in a workshop format and combined with probabilities and variance to quantify the uncertainty. The scenarios then produce actions utilized for R&D activities to adjust the product and service portfolio as well as business development, sales and marketing. A combination with expert business impact estimations produces a business forecast as input for midterm planning.

While a review of the scenario hit rate based on the probabilities showed a very good correlation with events that actually happened, the business forecast lacked the proper accuracy to be utilized in midterm planning. In order to improve the quality and accuracy of the business forecast, an element of the probabilistic modified trends school as described in chapter 2.4.3 was evaluated. The trend-impact analysis is a method to systematically generate an event-free trend as well as to define structured potential future events. The availability of historical business data is a key requirement. Based on this historical data, specific typical events that influence the motorsports industry, like the entry or exit of participating teams or major regulation changes, could be clearly defined. Another insight from the historical data was the potential impacts from changes in the competition as well as in the economy. The combined definition of events paired with the already existing scenarios generated a business forecast that showed vast improvements in accuracy. This improved

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accuracy of the business forecast is especially visible when combining the results from the trend-impact analysis based forecast of three previous scenario planning processes as shown in Figure 32.

Another benefit of detailed defined events in terms of magnitude and duration is that they can be automatically linked to the scenarios as well as to the global installed base. This link is implemented in an Microsoft Excel template to improve the usability and reduce the possibility of input error. With the availability of new business data in future scenario planning processes, the global installed base shown in Figure 24 and the event definition table shown in Figure 27 can simply be updated and paired accordingly with new created scenarios or during the semi-annual monitoring process. The forecast data are then automatically generated or updated and instantly available as input into the midterm planning.

The improvements in usability also reduce the time effort in using this tool. This is a very important factor in making sure that the scenario planning process and the according monitoring is repeated at the defined intervals, rather than loosing priority to other daily business activities. This was often the case in the past, especially when there have been changes in the participants involved in the process. Even though expert opinion for the definition of the scenarios is still essential, efficient and easy to use tools that help to reduce the required time effort are important to receive the needed acceptance for permanent implementation.

Scenario planning in general offers several different methods and tools that have their individual strengths and weaknesses as summarized in chapter 2.4. Based on the specific targeted outcome of the scenario planning process, a certain mix of these methods and tools is required to reach the desired quality. The determination of the optimum mix is difficult to achieve in an initial definition or setup, but rather requires several iterations and optimizations along the way. The current AVL RACING specific scenario planning process as an outcome of this thesis is a result of several iterations and optimizations. But it still is rather a status quo than a final solution that can be further optimized going forward.

6.2 Limitations

The review of the trend-analysis based business forecasts in chapters 5.1, 5.2 and 5.3 shows a drop in accuracy starting in year three of the forecast. This tendency is a

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result from the currently used five-year forecast horizon. Changes or additions to the test systems at the teams must be made one to two years prior to the entry into a race series or one year prior to a major regulation change in order to be available for the required R&D activities to prepare for these changes. Consequently, only events happening at the end of the five-year horizon have an effect on the business in year three. For the years four and five of the forecast horizon relevant events for business impact would already be in the future past the forecast horizon. To be able to create a proper five-year forecast the forecast horizon needs to be extended from currently five years to ten years.

Another limitation of the current scenario planning process is that it is only focusing on the existing obtainable market. The impact of extensions or shifts in the product and service portfolio, which could result in the penetration of new markets and the resulting business impact is currently not considered. A consideration of market extensions could either be an additional feature of the current scenario planning process or an additional tool that can be used in combination.

Even though the impact of a growing competition in the market is currently considered in the scenario definition, it is based on a general percentage assumption rather than derived from competitive intelligence. Incorporating available competitive intelligence in the definition of actions for R&D activities as well as in the business forecast would be another improvement in the quality of the scenario planning process.

6.3 Outlook

The open-response questionnaire used for stakeholder input is currently e-mail-based. This makes the effort to individually send the questionnaire and collect the response a time-consuming process. In addition, the responses within the received e-mails must be extracted and clustered manually. This process can be optimized by moving the questionnaire from e-mail to an online survey. The PESTEL-based feedback on factors and indicators for changes in the motorsports market can be already categorized into race series and category by user selection which would vastly improve the data collection process. Statistics on response rated would also be generated automatically.

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Extensions and improvements regarding limitations in new markets as well as the competition as described in chapter 6.2 could be implemented in the future while keeping the balance to a rather simple and time-efficient tool to use.

With the fact that the general automotive market has already become a very dynamic marketplace that is hard to predict, the goal is to introduce this scenario planning process also to other business segments within AVL once it is further optimized.

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List of Abbreviations

AST	Advanced Simulation Technologies
AVL	Anstalt für Verbrennungskraftmaschinen List
DTM	Deutsche Tourenwagen Meisterschaft
F1	Formula 1
FIA	Fédération Internationale de l'Automobile
GT	Grand Tourer
GTLM	Grand Tourer Le Mans
ITS	Instrumentation and Test Systems
NASCAR	National Association for Stock Car Auto Racing
OEM	Original Equipment Manufacturer
OI	Order Intake
PESTEL	Political, Economic, Social, Technological, Environmental and Legal
PTE	Powertrain Engineering
R&D	Research & Development
RASI	Responsible, Accountable, Support, Informed
TIA	Trend-Impact Analysis
UPM	Unified Planning Machinery
WEC	World Endurance Championship
WTCC	World Touring Car Championship

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Appendix A

Trend-impact analysis for the 2014 scenario planning process:

No.	Scenario	Probability	Variance	Series	Category	Impact	Year	2015	2015_w	2015_lo	2015_hi	2016	2016_w	2016_lo	2016_hi	2017	2017_w	2017_lo	2017_hi	2018	2018_w	2018_lo	2018_hi	2019	2019_w	2019_lo	2019_hi
1	New F1 Engine Manufacturer in 2018	20%	16%	F1	Engine	Entry	2016		0	0	0	20	4	0,8	7,2	1	0,2	0,04	0,36	1	0,2	0,04	0,36	1	0,2	0,04	0,36
2	Audi/VW to Join F1 in 2017	50%	25%	F1	Engine	Entry	2015	20	10	5	15	1	0,5	0,25	0,75	1	0,5	0,25	0,75	1	0,5	0,25	0,75	1	0,5	0,25	0,75
3	DynoPro/BobCat	100%	0%	Others	Engine	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
4	F1 Business	100%	0%	F1	Engine	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
5	Dodge return to NASCAR in 2017 with a new engine shop	15%	13%	NASCAR	Engine	Entry	2015	5	0,75	0,1125	1,3875	0,25	0,0375	0,005625	0,069375	0,25	0,0375	0,005625	0,069375	0,25	0,0375	0,005625	0,069375	0,25	0,0375	0,005625	0,069375
6	TRIAD aquiring CUP engine deals in 2016	30%	21%	NASCAR	Engine	Entry	2015	5	1,5	0,45	2,55	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275
7	V8 Supercars Engine business	30%	21%	GT	Engine	Entry	2016		0	0	0	2	0,6	0,18	1,02	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275
8	Haas formula developing full F1 car 2018	20%	16%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
9	New engine supplier in INDYCAR series 2018	20%	16%	IndyCar	Engine	Entry	2016		0	0	0	5	1	0,2	1,8	0,25	0,05	0,01	0,09	0,25	0,05	0,01	0,09	0,25	0,05	0,01	0,09
10	Hybrid powertrain in INDYCAR series 2018	30%	21%	IndyCar	Engine	Change +	2016		0	0	0	2	0,6	0,18	1,02		0	0	0		0	0	0		0	0	0
11	Competition gets stronger (Customer, K&S, MTS, OnoSokki, etc.)	50%	25%	Others	Engine	Comp	2015	-1,425	-0,7125	-0,35625	-1,06875	-1,425	-0,7125	-0,35625	-1,06875	-1,425	-0,7125	-0,35625	-1,06875	-1,425	-0,7125	-0,35625	-1,06875	-1,425	-0,7125	-0,35625	-1,06875
12	Global GT Race Competition 2017	80%	16%	GT	Engine	Change +	2016		0	0	0	5	4	3,2	4,8		0	0	0		0	0	0		0	0	0
13	New Race Series (i.e. Race without Driver, Fuel-Cell, etc.)	10%	9%	Others	Engine	Entry	2019		0	0	0		0	0	0		0	0	0		0	0	0	1	0,1	0,01	0,19
14	New F1 regulation in 2018	10%	9%	F1	Engine	Change +	2016		0	0	0	8	0,8	0,08	1,52		0	0	0		0	0	0		0	0	0
15	Formula E 2018	100%	0%	Formula E	Engine	Entry	2016		0	0	0	1	1	1	1	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25
16	Electric touring cars 2018	15%	13%	GT	Engine	Change +	2016		0	0	0	5	0,75	0,1125	1,3875	0	0	0	0	0	0	0	0	0	0	0	0
17	Global economic crisis 2016	15%	13%	Others	Engine	Eco_glob	2016		0	0	0	-3,563	-0,53445	-0,0801675	-0,9887325	-3,563	-0,53445	-0,0801675	-0,9887325		0	0	0		0	0	0
18	FIA is restricting the F1 powertrain testing because of cost saving	10%	9%	F1	Engine	Shift -	2015	-2	-0,2	-0,02	-0,38	-2	-0,2	-0,02	-0,38	-2	-0,2	-0,02	-0,38	-2	-0,2	-0,02	-0,38	-2	-0,2	-0,02	-0,38
19	Stepping out of F1 engine manufacturer in 2017	30%	21%	F1	Engine	Exit	2017		0	0	0		0	0	0	-1	-0,3	-0,09	-0,51	-1	-0,3	-0,09	-0,51	-1	-0,3	-0,09	-0,51
20	Each F1 Team gets a 3rd car	20%	16%	F1	Chassis	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
21	VW/Audi/Porsche sharing Testbed Facilities between their Brands	10%	9%	Others	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
22	New MercedesHPP Facility 2015	50%	25%	F1	Engine	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
23	non F1 4WD Integration Testbeds 2016	100%	0%	Others	Chassis	Base	2016		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
24	Mercedes 4WD TB 2015	80%	16%	F1	Chassis	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
25	WilliamsF1 4WD TB 2015	20%	16%	F1	Chassis	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
26	McLaren 4WD TB 2016	25%	19%	F1	Chassis	Base	2016		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
27	NASCAR Business	100%	0%	NASCAR	Engine	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
28	Penske Driveline Rig 2015	50%	25%	NASCAR	Chassis	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
29	Non F1/NASCAR	100%	0%	Others	Engine	Base	2015		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
	Base business based on Installed base	80%	16%			Trend		12,25	9,8	7,84	11,76	12,25	9,8	7,84	11,76	12,25	9,8	7,84	11,76	12,25	9,8	7,84	11,76	12,25	9,8	7,84	11,76
						Total			21,14	13,03	29,25		21,72	13,41	30,02		9,24	7,89	10,59		9,78	7,97	11,58		9,88	7,98	11,77

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Appendix B

Trend-impact analysis for the 2016 scenario planning process:

No.	Scenario	Probability	Variance	Series	Category	Impact	Year	2017	2017_w	2017_lo	2017_hi	2018	2018_w	2018_lo	2018_hi	2019	2019_w	2019_lo	2019_hi	2020	2020_w	2020_lo	2020_hi	2021	2021_w	2021_lo	2021_hi
1	New F1 Engine Manufacturer in 2020	35%	23%	F1	Engine	Entry	2018		0	0	0	20	7	2,45	11,55	1	0,35	0,1225	0,5775	1	0,35	0,1225	0,5775	1	0,35	0,1225	0,5775
2	DynoPro/BobCat	100%	0%	Others	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
3	F1 Business	100%	0%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
4	V8 Supercars Engine business	30%	21%	GT	Engine	Base	2019		0	0	0		0	0	0	2	0,6	0,18	1,02	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275
5	Haas formula developing full F1 car by 2020	30%	21%	F1	Chassis	Entry	2018		0	0	0	5	1,5	0,45	2,55	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275	0,25	0,075	0,0225	0,1275
6	New engine supplier in INDYCAR series by 2020	15%	13%	IndyCar	Engine	Entry	2018		0	0	0	5	0,75	0,1125	1,3875	0,25	0,0375	0,005625	0,069375	0,25	0,0375	0,005625	0,069375	0,25	0,0375	0,005625	0,069375
7	Hybrid powertrain in INDYCAR series by 2020	25%	19%	IndyCar	Engine	Change +	2018		0	0	0	2	0,5	0,125	0,875		0	0	0		0	0	0		0	0	0
8	One serious competitor for test system (Customer, K&S, MTS, D2T, etc.)	50%	25%	Others	Engine	Comp	2017	-1,475	-0,7375	-0,36875	-1,10625	-1,475	-0,7375	-0,36875	-1,10625	-1,475	-0,7375	-0,36875	-1,10625	-1,475	-0,7375	-0,36875	-1,10625	-1,475	-0,7375	-0,36875	-1,10625
9	Renault F1 testfield	50%	25%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
10	PTE competition increasing	50%	25%	Others	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
11	Global GT hybrid powertrain formula 2019	10%	9%	GT	Engine	Change +	2018		0	0	0	6	0,6	0,06	1,14		0	0	0		0	0	0		0	0	0
12	New Race Series (i.e. Race without Driver, Fuel-Cell, etc.) by 2020	10%	9%	Others	Engine	Entry	2018		0	0	0	1	0,1	0,01	0,19	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095
13	New F1 regulation in 2020	50%	25%	F1	Engine	Change +	2018		0	0	0	8	4	2	6		0	0	0		0	0	0		0	0	0
14	Formula E 2019	100%	0%	Formula E	Engine	Entry	2017	1	1	1	1	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25
15	Electric touring cars by 2020	50%	25%	GT	Engine	Change +	2018		0	0	0	6	3	1,5	4,5		0	0	0		0	0	0		0	0	0
16	Global economic crisis in 2017	25%	19%	Others	Engine	Eco_glob	2016	-3,688	-0,922	-0,2305	-1,6135	-3,688	-0,922	-0,2305	-1,6135		0	0	0		0	0	0		0	0	0
17	FIA is restricting the F1 powertrain testing because of cost saving	35%	23%	F1	Engine	Shift -	2018		0	0	0	-2	-0,7	-0,245	-1,155	-2	-0,7	-0,245	-1,155	-2	-0,7	-0,245	-1,155	-2	-0,7	-0,245	-1,155
18	Stepping out of F1 engine manufacturer in 2018	10%	9%	F1	Engine	Exit	2015		0	0	0	-1	-0,1	-0,01	-0,19	-1	-0,1	-0,01	-0,19	-1	-0,1	-0,01	-0,19	-1	-0,1	-0,01	-0,19
19	Each F1 Team gets a 3rd car	10%	9%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
20	VW/Audi/Porsche sharing Testbed Facilities between their Brands	10%	9%	Others	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
21	New MercedesHPP Facility	35%	23%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
22	non F1 4WD Integration Testbeds	100%	0%	Others	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
23	Mercedes 4WD TB	30%	21%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
24	WilliamsF1 4WD TB	10%	9%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
25	NASCAR Business	100%	0%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
26	Renault 4WD TB	35%	23%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
27	McLaren 4WD TB	35%	23%	F1	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
28	Penske Driveline Rig	20%	16%	NASCAR	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
29	Non F1/NASCAR Base business	100%	0%	Others	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
30	HPP Fuel Rig	70%	21%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
31	Toyota WRC - Tommi Mäkkinnen making the engine	10%	9%	Rally	Engine	Entry	2017	1,5	0,15	0,015	0,285	0,25	0,025	0,0025	0,0475	0,25	0,025	0,0025	0,0475	0,25	0,025	0,0025	0,0475	0,25	0,025	0,0025	0,0475
32	Hyundai Engine Testbed	50%	25%	Rally	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
33	Hendrick Driveline	50%	25%	NASCAR	Chassis	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
34	HPD new testcell 2017	35%	23%	IndyCar	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
35	TRD Valverigs 2018	50%	25%	NASCAR	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
36	TRD move to NC in 2018	65%	23%	NASCAR	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
37	Honda eME	80%	16%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
38	New Manufacturer in WEC 2020	35%	23%	WEC	Engine	Entry	2018		0	0	0	5	1,75	0,6125	2,8875	1	0,35	0,1225	0,5775	1	0,35	0,1225	0,5775	1	0,35	0,1225	0,5775
39	Red Bull F1 Engine Program for 2014 regulation	33%	22%	F1	Engine	Entry	2017	20	6,6	2,178	11,022	1	0,33	0,1089	0,5511	1	0,33	0,1089	0,5511	1	0,33	0,1089	0,5511	1	0,33	0,1089	0,5511
40	Yamaha to get 3rd party AuSy	25%	19%	MotoGP	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
41	Honda supplying F1 engine to second team	50%	25%	F1	Engine	Base	2017		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
42	NASCAR Engine rule change: engine limitation 2018	25%	19%	NASCAR	Engine	Shift -	2018		0	0	0	-1,5	-0,375	-0,09375	-0,65625	-1,5	-0,375	-0,09375	-0,65625	-1,5	-0,375	-0,09375	-0,65625	-1,5	-0,375	-0,09375	-0,65625
43	DTM regulation change 2019	50%	25%	GT	Engine	Change +	2029		0	0	0	6	3	1,5	4,5		0	0	0		0	0	0		0	0	0
44	New manufacturer in DTM in 2019	35%	23%	GT	Engine	Entry	2017	2	0,7	0,245	1,155	0,25	0,0875	0,030625	0,144375	0,25	0,0875	0,030625	0,144375	0,25	0,0875	0,030625	0,144375	0,25	0,0875	0,030625	0,144375
45	IRL getting out of business	20%	16%	IndyCar	Engine	Exit	2017	-0,5	-0,1	-0,02	-0,18	-0,5	-0,1	-0,02	-0,18	-0,5	-0,1	-0,02	-0,18	-0,5	-0,1	-0,02	-0,18	-0,5	-0,1	-0,02	-0,18
46	Fuel Cell Racecar	25%	19%	Others	Engine	Entry	2017	1	0,25	0,0625	0,4375	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875
47	Peugeot to return to WEC/LMP1 in 2018	50%	25%	WEC	Engine	Entry	2017	5	2,5	1,25	3,75	1	0,5	0,25	0,75	1	0,5	0,25	0,75	1	0,5	0,25	0,75	1	0,5	0,25	0,75
	Base business based on Installed base	80%	16%			Trend		12,75	10,2	8,16	12,24	12,75	10,2	8,16	12,24	12,75	10,2	8,16	12,24	12,75	10,2	8,16	12,24	12,75	10,2	8,16	12,24
						Total			19,64	12,29	26,99		30,78	16,69	44,88		10,97	8,55	13,38		10,44	8,40	12,49		10,44	8,40	12,49

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Appendix C

Trend-impact analysis for the 2018 scenario planning process:

No.	Scenario	Probability	Variance	Series	Category	Impact	Year	2019	2019_w	2019_lo	2019_hi	2020	2020_w	2020_lo	2020_hi	2021	2021_w	2021_lo	2021_hi	2022	2022_w	2022_lo	2022_hi	2023	2023_w	2023_lo	2023_hi
1	Electric/Hybrid Racing/Street Courses 2022	70%	21%	Others	Engine	Entry	2021		0	0	0		0	0	0	1	0,7	0,49	0,91	0,5	0,35	0,245	0,455	0,5	0,35	0,245	0,455
2	Rising interest in emerging markets for motorsports 2021	80%	16%	Others	Engine	Entry	2021		0	0	0	0	0	0	0	1	0,8	0,64	0,96	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48
3	Competition gets stronger (Customer, K&S, MTS, OnoSokki, etc.)	50%	25%	Others	Engine	Comp	2015	-1,575	-0,7875	-0,39375	-1,18125	-1,575	-0,7875	-0,39375	-1,18125	-1,575	-0,7875	-0,39375	-1,18125	-1,575	-0,7875	-0,39375	-1,18125	-1,575	-0,7875	-0,39375	-1,18125
4	New ownership of NASCAR - 2021 Season	50%	25%	NASCAR	Engine	Base	2021		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
5	Additional Manufacturer in NASCAR - 2020	50%	25%	NASCAR	Engine	Entry	2019	5	2,5	1,25	3,75	0,25	0,125	0,0625	0,1875	0,25	0,125	0,0625	0,1875	0,25	0,125	0,0625	0,1875	0,25	0,125	0,0625	0,1875
6	New F1 PU supplier 2021	90%	9%	F1	Engine	Entry	2019	20	18	16,2	19,8	1	0,9	0,81	0,99	1	0,9	0,81	0,99	1	0,9	0,81	0,99	1	0,9	0,81	0,99
7	New IndyCar PU supplier in 2022	25%	19%	IndyCar	Engine	Entry	2020		0	0	0	5	1,25	0,3125	2,1875	0,25	0,0625	0,015625	0,109375	0,25	0,0625	0,015625	0,109375	0,25	0,0625	0,015625	0,109375
8	Change in LMP/GT-P - 2021/22	80%	16%	WEC	Engine	Change +	2021		0	0	0		0	0	0	2	1,6	1,28	1,92		0	0	0		0	0	0
9	New players coming from gaming/e-sports/Apples/Googles 2022	30%	21%	Others	Engine	Entry	2021		0	0	0		0	0	0	1	0,3	0,09	0,51	0,5	0,15	0,045	0,255	0,5	0,15	0,045	0,255
10	Split of FCA - Dodge back in NASCAR 2023	50%	25%	NASCAR	Engine	Entry	2021		0	0	0		0	0	0	5	2,5	1,25	3,75	0,25	0,125	0,0625	0,1875	0,25	0,125	0,0625	0,1875
11	Technology change in Power Units. DU, Turbo, Fuel Limited, Efficiency, Electrified, Emissions	50%	25%	Others	Engine	Change +	2020		0	0	0	0,5	0,25	0,125	0,375	0	0	0	0	0	0	0	0	0	0	0	0
12	F1 Budget limitations/no significant increase in spending	25%	19%	F1	Engine	Shift -	2019	-2	-0,5	-0,125	-0,875	-2	-0,5	-0,125	-0,875	-2	-0,5	-0,125	-0,875	-2	-0,5	-0,125	-0,875	-2	-0,5	-0,125	-0,875
13	Motorsports will become less of a valid marketing instrument, competing with other sports or activities	40%	24%	Others	Engine	Shift -	2021		0	0	0		0	0	0	-0,5	-0,2	-0,08	-0,32	-0,5	-0,2	-0,08	-0,32	-0,5	-0,2	-0,08	-0,32
14	being successful in attracting new audiences via new technologies, engagement, augmentation	50%	25%	Others	Engine	Shift +	2016	0,5	0,25	0,125	0,375	0,5	0,25	0,125	0,375	0,5	0,25	0,125	0,375	0,5	0,25	0,125	0,375	0,5	0,25	0,125	0,375
15	Value for Cost	50%	25%	Others	Engine	Base	2020		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
16	Platform to market new road car technologies	80%	16%	Others	Engine	Shift +	2020		0	0	0	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48
17	US politics helps to sustain/grow motorsports in the US	25%	19%	Others	Engine	Shift +	2019	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875	0,5	0,125	0,03125	0,21875
18	Environmental policies: reduction of fossil fuels, pollution; push for alternative fuels, different technologies	80%	16%	Others	Engine	Shift +	2020		0	0	0	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48	0,5	0,4	0,32	0,48
19	National funding for motorsports (new, AotF is a start)	75%	19%	Others	Engine	Base	2019		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
20	Economical crisis/wealth	30%	21%	Others	Engine	Eco_glob	2019	-3,938	-1,1814	-0,35442	-2,00838	-3,938	-1,1814	-0,35442	-2,00838		0	0	0		0	0	0		0	0	0
21	Hard Brexit	50%	25%	Others	Engine	Eco_reg	2019	-0,984	-0,492	-0,246	-0,738	-0,984	-0,492	-0,246	-0,738		0	0	0		0	0	0		0	0	0
22	US/China Trade War	50%	25%	Others	Engine	Eco_reg	2020		0	0	0	-0,984	-0,492	-0,246	-0,738	-0,984	-0,492	-0,246	-0,738		0	0	0		0	0	0
23	Overhead CAM for NASCAR in 2022	50%	25%	NASCAR	Engine	Change +	2021		0	0	0		0	0	0	9	4,5	2,25	6,75		0	0	0		0	0	0
24	ICE efficiency increase outside F1, WEC, F-E; fuel limitations; emission limitation; pre-chamber	80%	16%	Others	Engine	Change +	2020		0	0	0	0,5	0,4	0,32	0,48		0	0	0		0	0	0		0	0	0
25	New F1 2021 PU regulations	80%	16%	F1	Engine	Change +	2020		0	0	0	10	8	6,4	9,6		0	0	0		0	0	0		0	0	0
26	Slower pace in regulation changes (F-E vs. NASCAR)	25%	19%	NASCAR+FE	Engine	Shift -	2019	-2,5	-0,625	-0,15625	-1,09375	-2,5	-0,625	-0,15625	-1,09375	-2,5	-0,625	-0,15625	-1,09375	-2,5	-0,625	-0,15625	-1,09375	-2,5	-0,625	-0,15625	-1,09375
27	Increased electrification/hybridization	80%	16%	Others	Engine	Base	2020		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
28	Standard F1 GBX	25%	19%	F1	Chassis	Change -	2019	-6	-1,5	-0,375	-2,625		0	0	0		0	0	0		0	0	0		0	0	0
29	Balance of Performance	60%	24%	Others	Engine	Shift -	2019	-0,5	-0,3	-0,18	-0,42	-0,5	-0,3	-0,18	-0,42	-0,5	-0,3	-0,18	-0,42	-0,5	-0,3	-0,18	-0,42	-0,5	-0,3	-0,18	-0,42
30	More interaction between PU and chassis	80%	16%	Others	Engine	Base	2020		0	0	0		0	0	0		0	0	0		0	0	0		0	0	0
31	More Track testing restriction	10%	9%	Others	Engine	Shift +	2019	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095	0,5	0,05	0,005	0,095
32	F1 Lab testing limitations	50%	25%	F1	Engine	Shift -	2019	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5
33	F1 Power Units need to last longer	50%	25%	F1	Engine	Shift -	2019	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5	-2	-1	-0,5	-1,5
	Base business based on Installed base	80%	16%			Trend		13,25	10,6	8,48	12,72	13,25	10,6	8,48	12,72	13,25	10,6	8,48	12,72	13,25	10,6	8,48	12,72	13,25	10,6	8,48	12,72
						Total			24,14	23,26	25,02		16,37	14,61	18,13		18,41	13,99	22,83		9,53	8,91	10,14		9,53	8,91	10,14