Business Plan

for

Flex Hex IVS

FEBRUARY 2019

Flex Hex
ROBOTICS
COMPANY

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2 Executive summary

Constantly increasing competition and pricing pressures in the manufacturing industry lead to an intensified demand for higher productivity and shorter time-to-market strategies. Rising diversity and model variety and shorter life cycle time require more flexible production plants. This leads to an intensified demand for new production concepts. The market for reconfigurable tooling is therefore growing, since they are among the major cost drivers in product industrialization. Reconfigurable tooling is already introduced in the market, but the existing solutions are very costly and not economically to make investments in.

Dr. Igor Kovac[1] has in response to these issues invented Hexapod which is a reconfigurable fixture and will in collaboration with Flex Hex, and ELESTRA, market, produce and sell solutions using Hexapods. Hexapod is an economical, flexible and high-quality fixture which can ensure higher stiffness and accuracy in fixating workpieces in e.g. a production line. The solution is especially relevant in the manufacturing industry, both at small and larger plants and batch sizes. But many more industries could find utilization. Also, within several industrial applications Hexapods can come in great use. This makes the potential market for Hexapod quite extensive and alone in Europe a great number of the solution is potentially coveted.

Figure 1: The Flex Hex solution: Hexapod

The vision of the Flex Hex Company is to develop, produce and market Hexapod solutions with the aim of supplying complete integrated solutions. Hexapod is completely integrated within the robot activities in production lines, and the merging of the two technologies leads to an economical, flexible and high-quality fixture that ensures higher stiffness and accuracy in fixating workpieces in e.g. a production line responding to the market needs.

Product test have been completed with end users and have had very good results, which makes the business case for Hexapod strong. Hexapod is both more flexible, accurate, faster and cheaper than the existing solution; *Non-mechanical fixture* and investment costs are much lower than the competing solution; *Motor driven fixtures*.

The organization behind Flex Hex IVS. consist of Igor Kovac, CEO Laurent Marquis and production partner ELESTRA (see section 7 for further information).

Today, the opportunity of getting inside the industrial production method market is wise and high, indeed many industries needs to find new innovative solution to optimize their production, increasing efficiency, developing lean manufacturing (no waste) and allow easy customization of their product.

[1] Researcher at Josef Stefan Institute in Slovenia. Inventor and developer of Hexapod and partner in the company.

The industry 4.0 concept has been highly developed by the automotive industry and is going to be these years the main issue for other production industries. Even automotive industries and their suppliers are looking intensively to new solution which can change their production lines. (BMW has opened a topic for "new method to present welding fixture on a car body manufacturing line", our proposal with Flex Hex system is under consideration)

Flex Hex IVS. is looking for investors who can contribute with approximately 0,55 M€ on the long run but plans to raise 250.000€ in a first step, to start up the company and secure a customer base for the next 12 months. Flex Hex IVS intends to convert the company to an ApS, eventually A/S as soon as milestone 3 on sales as been reached (more than 60 hexapods sold).

3 Industrial automation and current challenges

Rapid changes in market demands lead to decreasing product life cycle times and more frequent product launches. The rising diversity and model variety as well as the shorter life cycle times require more flexible production. An enterprise need to react fast, efficiently, and in an economically justified way to market changes. More frequent changeovers in a product type or in several products require new engineering and production methodologies and machinery equipment to enable shorter set-up times of production environments. Robots as highly flexible devices have been successfully utilized in many industrial production processes. Industrial robots can be applied to execute complex repetitive tasks, often faster, more reliably, and more precisely than human workers. Despite of these facts, many processes e.g. assembly and processing within the manufacturing industry still has not been automated, mainly due to high set-up costs and long set-up times.

However, many enterprises are still reluctant to purchase robots for many types of tasks e.g. assembly tasks. The main hindrances are complexities involved in setting-up robotic–based automated solutions because these usually require expert knowledge and significant time for testing and fine-tuning. Since many enterprises usually do not have this knowledge capacity, they avoid introducing such solutions, even when they are economically justifiable. Looking at robotic systems in more detail, we see that these problems are due to the time needed to reconfigure and reprogram the robot for a new task (as well as ongoing maintenance), which are often too long to make the application of robots profitable.

Current pains count many, but on top of this list is price and time. The existing solutions relate either to very heavy investments due to purchasing price or to long set-up times and demands many man-hours due to requirements of e.g. positioning precision in production, which also makes them very costly. Besides this there is a higher need of flexibility provided understood in terms of ability to reconfigure efficiently, degrees of freedom, opportunities for movement e.g. in a production line etc. Furthermore, stiffness which ensures accuracy in production needs to be improved, to make production more reliable and minimize issues in this matter.

Due to recent developments within robot programming, fast reconfigurable machinery, vision technologies, modelling and simulation, it is possible to develop a new reconfigurable unit for a robot work cell to automate industrial tasks and therefore, reconfigurable equipment like Hexapod will enable the use of autonomous robots in further applications. In this way robots will reconfigure and build its own working place to assemble products of different sizes and shapes. These technologies have become sufficiently mature to achieve new breakthroughs in the utilization of robots everywhere in production.

3.1 Needs on the market

Use of dedicated fixtures and jigs to assemble, weld or manufacture topics is typical in many industries. This spans from big element production e.g. car production to small element production and from large series of products to small series of products. The use of dedicated fixtures and jigs requires hours of engineering, manufacturing time and significant storage capacities. Furthermore, the time imposed by changing the fixture in the manufacturing line increases the leading time and slows down the production process.

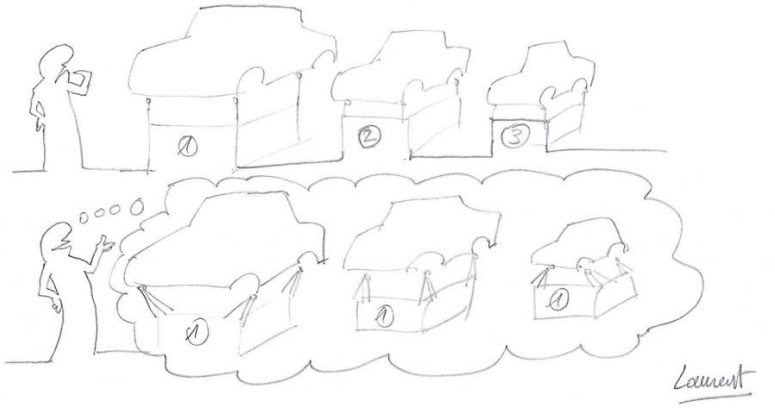


Figure 2: Production line example in a large item production before and after the Flex Hex solution

It is also important to notice the dramatic changes which have happened in recent years in industrial processes. Here customization of products is an increasing requirement from end-customers, while keeping storage of finished parts as low as possible for the producing companies. This means higher flexibility with small production batches, just-in-time deliveries and increasing production changes during the day.

For producers who have smaller lots and must change products more frequently, an automatic reconfiguration and adaption of jigs and fixtures system will allow them to optimize their production by merging the production equipment, avoid leading time and reduce cost under the condition that the solution proposed is adaptable inside the production line and competitive in terms of ROI. Thus, many factors are playing a role and emphasize a search for a more flexible solution.

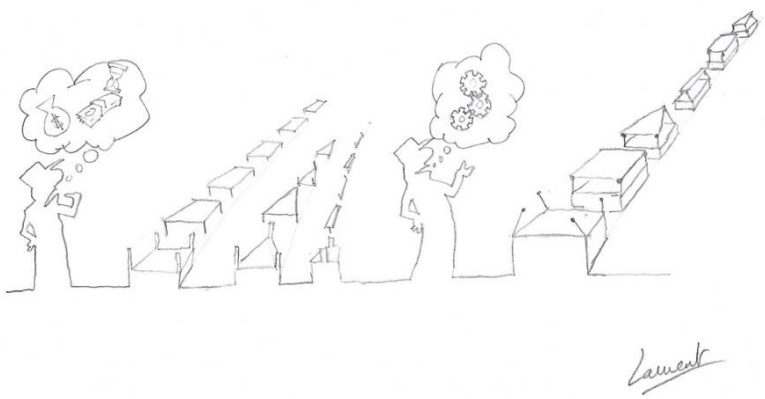


Figure 3: Production line example in a small items production before and after the Flex Hex solution

Today, there are two ways of having fixtures and jigs, which are either very inefficient or highly priced, making them both very costly to operate. One way is having dedicated fixtures made by an engineer or a welder, the other way is having motor driven solutions which reconfigure automati-

cally. The Flex Hex concept is an economical fixture which fast can reconfigure using the environment available, for instance existing robots, allowing the solution to be both efficient in both a time and an economical perspective.

3.2 The Flex Hex solution

The idea of the Flex Hex solution is to make the dedicated jigs and fixtures in the production, which are used to e.g. assemble, weld or manufacture the topics together; flexible, reconfigurable, reusable and transportable at a reasonable price. Further, it is the goal that this solution shall avoid leading time, expensive engineering design work, while also exclude manufacturing and storage need of fixtures.

This is now possible with the Flex Hex solution where several Hexapods (determined by individual user-situation) are placed on anchoring points in a production line. The hexapods can either be positioned by existing robots or manually and fixed in an accurate position through an effective clamping system and no backlash from the rotation joints. The existing robot then place different tools on top of the Hexapod to support the production process, e.g. clamping devices. The Hexapod can then again reposition by help from an existing robot.

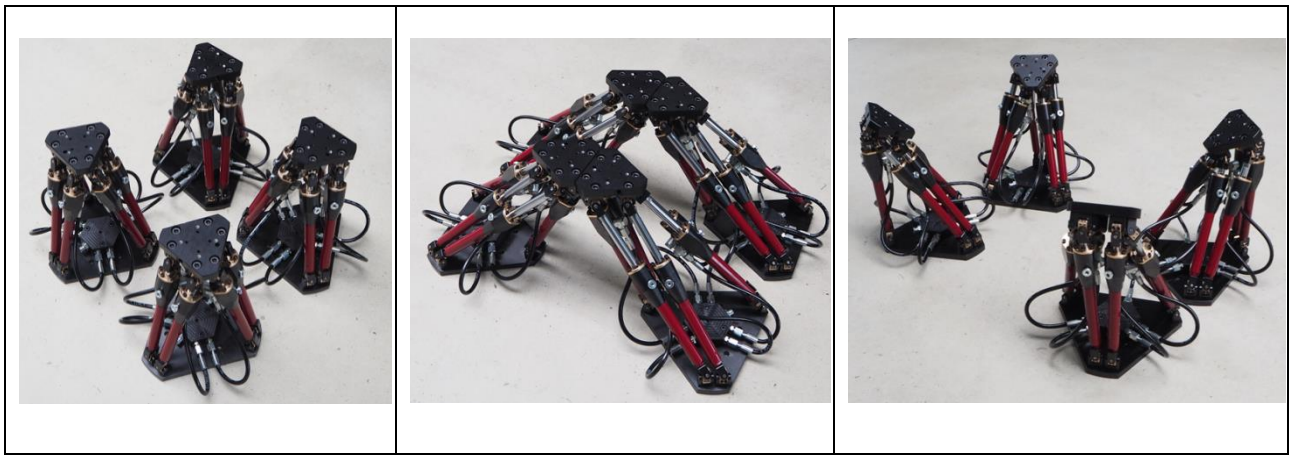


Figure 4: The flexible hexapod can be repositioned to any possible position in a large accessible volume

Hexapod is more flexible, accurate, faster and cheaper than dedicated fixtures, which is the most common solution in the market today and investment costs are much lower than the competing solution which is motor driven fixtures.

Typically, a dedicated fixture costs 5-10.000€, cost which should be multiplied by the necessary number of fixtures for each item. On top of this, design and manufacturing of new dedicated fixtures must be added for each of them. On the other side, motor driven fixtures with 4 hexapods costs more than 100.000€ and necessity special programming of the cell. The Flex Hex solution containing 4 passive hexapods costs around 30.000€ and is integrated in the existing cell using the existing environment, robot arm, for the positioning of the hexapods.

Product test have been completed with end users and have had very good results, which makes the business case for Hexapod strong.

Igor Kovac is the inventor of the Hexapod and will in collaboration with the CEO Laurent Marquis and ELESTRA produce, bring to market and sell Hexapod solutions. The potential market for Hexapod is quite extensive, since it has high usability within several industries and set-ups and alone in Europe a great number of the solution is potentially sought-after.

3.3 Workflow with the Flex Hex concept

The work of the all process using one robot to repositioning the hexapod, placing the tool on the top of it, making the assembly or welding operation, taking the finished part out of the fixture and placing the hexapod again for the next production process, can be illustrated as followed:

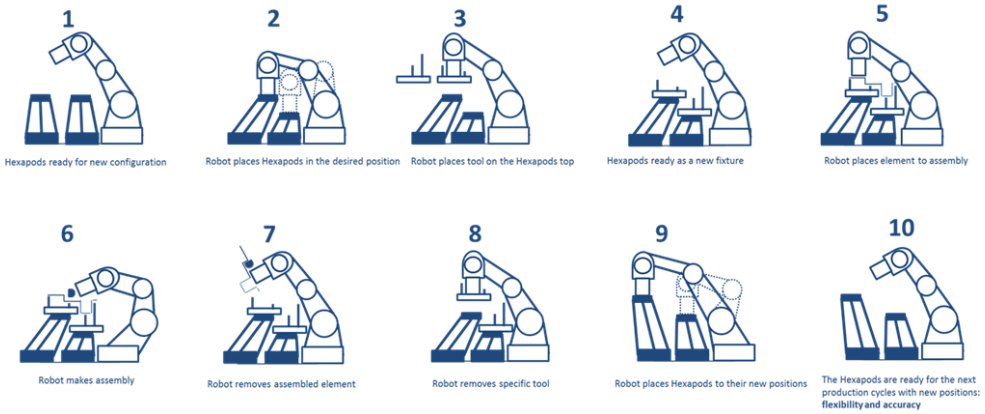


Figure 5: Workflow for the Flex Hex concept

4 Hexapod product platform

4.1 Product description: keep it simple!

The Flex Hex concept, *Hexapod*, is a flexible and reconfigurable alternative to dedicated jigs and fixtures used mainly in production. Utilized for assembly, welding and manufacturing, the Flex Hex concept enables a more cost-effective production line setup, reduced fixture storage and a quicker adaption to other production series. The hexapod is a passive but efficient fixture which uses the existing production environment (robot arm) for the positioning of it: less complexity and low cost.

The Flex Hex concept consists of several Hexapods – the number depends of the fixture configuration. Hexapod is a robot fixture which can be featured with passive reconfigurable and adaptive tooling on the base plate. It can be reconfigured either automatically by a robot or manually.

There are many benefits to the use of these flexible systems, some of these are as follows:

- Reduction of change-overtime due to automatic reconfiguration of the production cell/place
- Increases cost efficiency through the re-use of fixture components on multiple projects
- Reduces fixture design lead times due to the use of dedicated design apps
- Removes the limitations of traditional fixture design which requires component geometry and datum's to be locked months in advance of manufacture
- Cuts fixture build lead times due to the use of off-the-shelf modular components
- Facilitates single piece flow on multi product processes
- Reduce storage space for dedicated fixture

Hexapod is illustrated in figure 6 below. The solution consists of a lower platform which is called base plate. On top of this, six universal joints are placed, which connect the base plate to the passive linear elements that leads up to the upper platform called top plate. There are 6 passive linear elements to ensure 6 degrees of freedom and flexibility. Beside the Hexapod a hydraulic pressure intensifier is placed. This unit generates an internal oil hydraulic pressure, which clamps passive linear elements to stay in a predefined position. Oil hydraulic pressure releasing makes movement of the passive linear elements possible. On the top plate it is possible to place a clamping jig. The clamping jig shall grab the workpiece and make sure to hold this stiff and tight, to make it possible for others - either robots or manpower to work with and on the workpiece.

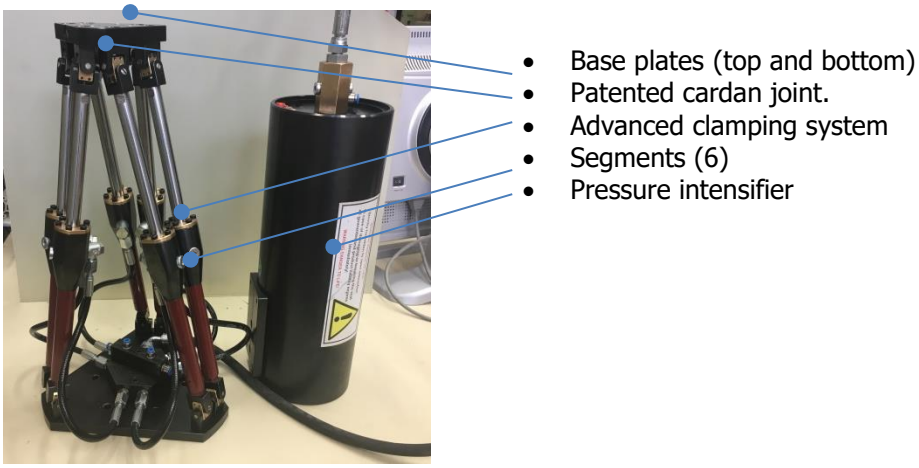


Figure 6: Illustration of Hexapod

Since Hexapod is a passive reconfigurable fixture, it requires no motors, no cables and no wires. This is possible due to a hydraulic system with a pressure intensifier, controlled by a single pneumatic valve which effectively release and activate the hydraulic clamping system around the segment securing an accurate position.

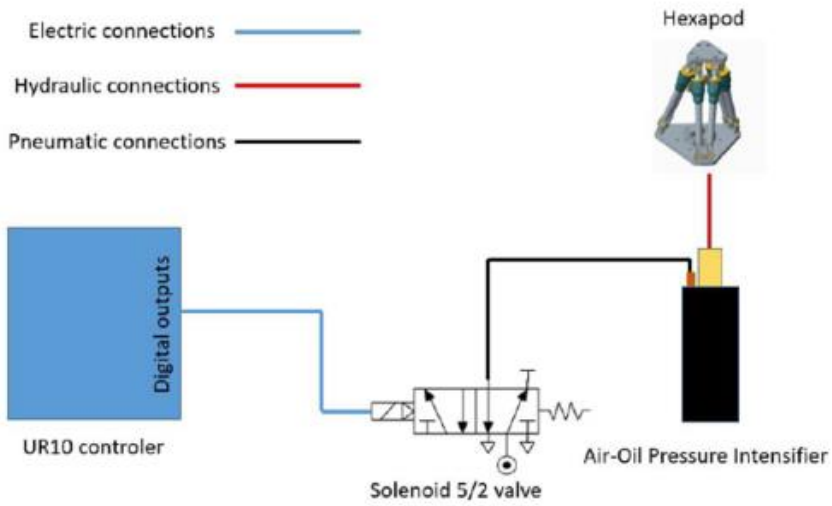


Figure 7: Illustration of the mechanisms behind Hexapod

This makes the Hexapod much more flexible in use situations, especially in e.g. production lines in automotive industry, while also assuring the ability to keep clamping position is case of power failure or disconnecting the fixture from extern power when moving on the production line. This also makes Hexapod itself non-autonomous, which means it must be reconfigured manually or with the use of external moving equipment, e.g. a robot. This reconfiguration can take between 5-30 seconds depending on method used and degree of difficulty of the reconfiguration. Hexapod is as of today produced and tested as prototypes in different sizes, and thus can be produced within a wide range of sizes.

As mentioned Hexapod has a movement of 6 degrees of freedom which increases the flexibility, while ensuring maximum work space and modular structure. Figure 8 is an illustration which shows an extract of different positions possible for Hexapod. Furthermore, Hexapod ensures high stiffness, sufficient positioning accuracy, no use of a medium to maintain the set position.

When inventing and making the Hexapod it has been a priority that it should be an economical solution for the different industries that could have an interest in utilizing the solution. Therefore, the construction method has been made with this goal and the components used are standard parts. This ensures an economical and competitive reconfigurable solution.

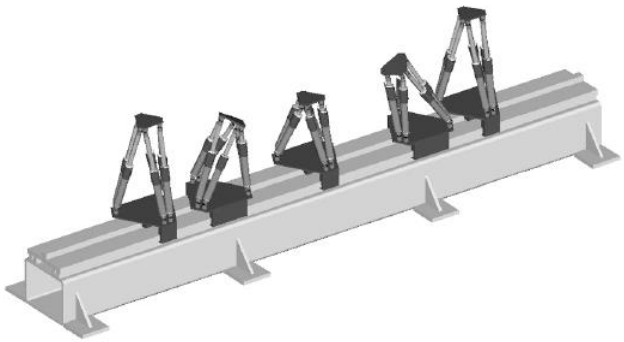


Figure 8: Illustration of Hexapod's position possibilities

4.2 Patent

The patent owners are Igor Kovač (97%) and Josef Stefan Institute JSI (3%) and has been transferred to the company with a license agreement to JSI. Two evaluations have been made on the novelty of the patent application (one in UK and one in Denmark) with positive responses and the patent is now registered as PCT EP2018/060387. The patent describes the accurate mechanism,

control and adjustment of the backlash for the cardan used for the movement of the Hexapod. Flex Hex sees further possibilities for patent application on the system.

4.3 Size

Hexapod can as of today be produced in 2 different sizes; small (10kg payload) and medium (50kg payload) and a large one has been calculated. The small solution can handle a workpiece that weighs up to 100 kg and has a displacement area up to 130 mm, while the medium solution can handle workpieces weighing up to 500 kg, has a displacement area up to 200mm and the large solution can handle workpieces that weighs up to 1.500 kg. Thus, if a production line consists of 6 small Hexapods the workpiece can weigh up to 600 kg, with the anticipation that the weight is equally distributed in the workpiece.

A new size is under design for smaller application as potential customers are asking for it, typically for welding cells where the need of working loads is lower, in the range of 5-8kg payload, with a maximum peak load of 70kg (during processing), a shorter displacement area, up to 80mm.

4.4 Fixture use cases

Hexapod can be used in several processes, since there is no need of electricity. Production lines are situations where the Hexapod will be optimal, but several other processes and industries can benefit from the use of Hexapods.

Within assembly applications, enterprises herein can be divided into three large groups; big element production, medium element production and small element production, which then each can be divided in batch sizes, few or many. Major industries which produces large batch sizes are e.g. automotive and aviation industry. Within automotive a use case could especially be in automotive assembly line, also called body-in-white and assembly of plastic components. But it is also relevant in assembling other automotive parts, while in the aviation industry it could be in assembling mechanical parts. Industries with medium and smaller element production could e.g. be assembling furniture, motors, etc. The Hexapod is also very relevant in use cases where very small batch sizes are made why the production line need to be changed often, whether elements may be small or large. In general, the Hexapod can be utilized in all situations where assembling of two or more parts is needed.

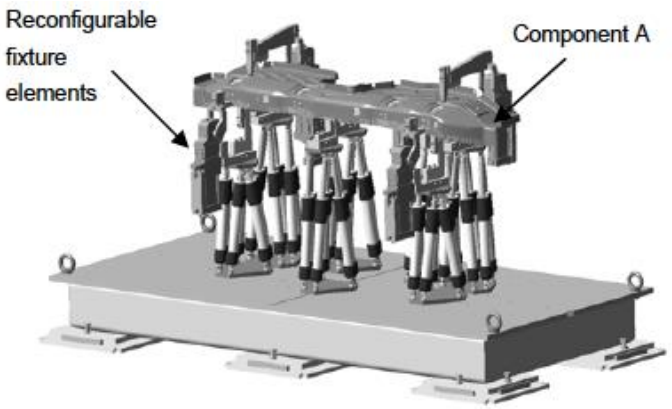


Figure 9: Illustration of 6 Hexapods fixating a workpiece

When operating with applications within welding it is optimal for manual support, since it can be used in both fixation and positioning tasks. Furthermore, when using Hexapods there will be a big database which can be an aid for documentation and clarification of when and where either success or failure regarding welding situations occurred.

Within processing applications, the Hexapod can be utilized as an equipment supporting when fixating the workpiece to be able to e.g. use applications within machining or surface treatment. These tasks are numerous and could consist of e.g. drilling, welding, grinding, reaming, tapping, polishing, painting, shaping operations etc.

The solution is also useful for the postprocessing of 3D print, as items need to be machined after the process and typically the production is just few items. Machining of these produced items from the 3D printing process, require developing specific fixture for every item, which can be favourably exchange by flexible fixtures.

New opportunities can be within the wind turbine wings production as it requires expensive moulds which are adapted for each project (the mould must be changed according to new site characteristics: wind direction, wind speed, loads…). A solution containing hexapods for making the mould adaptable could be a way of reducing expensive changes on it and gives the possibilities of changing geometrical parameters easily and fast.

4.5 Maintenance

Tests have shown that Hexapod is in no need of extensive ongoing service. These tests have been made on the medium version of the solution, which have given reasons to believe that extensive service is not needed on any of the sizes. The low need of maintenance is due to the design and construction of Hexapod and especially the hydraulic solution minimizes the risks of complication and breakdown. While reducing risks and problems, there are also some foreseen maintenance aspects that needs to be addressed, which is caused by the hydraulic system. This could be adjustment of oil pressure in the hydraulic pressure intensifier. But this is relatively limited and easy. Another aspect is about the production of the passive linear elements, if this is not produced and/or assembled correctly, there is a risk of oil leakage or spill, which will cause a problem. But this problem and risk lies in the production of the Hexapod, why it will not create a problem for the user of the solution.

4.6 Projects

Flex Hex IVS. with its partners; Blue Ocean Robotics in Denmark, ELESTRA and ELVEZ both situated in Slovenia, has been supported by the Danish Innovation Fund, the Innobooster, to prepare a proof of concept study on a real production line. This project focuses on developing a concept from a standalone product to an integrated flexible fixture in an industrial production environment at the ELVEZ company which produce head light for cars.

Flex Hex IVS is responsible for specification definition, development of mechanical components and positioning system, end-user interface (registration and validation of position) and finally FAT test. ELESTRA is responsible for manufacturing components, assembly and in-house testing. ELVEZ, the end-user, helps to define the specification and the development tasks to integrate the system in their production and will make the final test approval validation. The Innobooster fund supports the project by refunding 32% of hour's price and components price.

4.7 Research & Development

Flex Hex has already anticipated the next requirement from the market by interviews of potential customers.

As the system locking mechanism is based on hydraulic, some customers want to avoid the use of hydraulic. Studies have been started and discussion with suppliers to use water hydraulic instead. It will require some changes in some parts but definitively possible.

For systems requiring more than 4 hexapods, it will be preferable to exchange the simple pressure intensifier on each hexapod by a hydraulic station controlling all 4 and be able to be increase easily

if more hexapods must be connected. A working group has been started with hydraulic suppliers and some solution have been proposed, also including the use of hydraulic water.

For some application, due to requirement of intensive documentation from production, a position feedback will be needed to follow the fixture geometrical position (quality control). Flex Hex has already developed a position feedback placed on each legs of the hexapod with a very accurate feedback (<0,01mm) but need to develop the algorithm for all 6 legs and the software interface to the control system for data management (control and recipes possibility for changing from item to item).

5 The market

The market for reconfigurable tooling is growing, since they are among the major cost drivers in product industrialization. The usage of Hexapod spans over a wide variety of possibilities and can potentially be used in several industries as mentioned in paragraph 4. Therefore, the market for Flex Hex is large as any industry with a production process including fixtures or jigs can have an interest in making their production process more flexible. It has of course to be seen in parallel with the investment needed, the turnover in production changes and quantity of pieces to produce. The Flex Hex company intends to help customers to define the most optimal configuration (size, quantity, emplacement of Hexapod, usage of existing robots or new robots on the line when positioning, new structure or reusing existing jigs, etc.) and will design a complete solution to the customer.

5.1 Segmentation of the market

The market can be segmented into several categories and groups, since the usage of Hexapods spans over a wide variety of possibilities and can potentially be used in several industries. Especially within the manufacturing industry, there exists a great potential, since many of the enterprises herein use production line facilities, which potentially can be optimized, why the following analysis will have its starting point here. Within manufacturing there exist a wide variety of customers. In one end, there is the small production companies, which produces small batches and have many changes during production. In the other end, there is the very big production companies, which produces large batches, but are still constrained by high costs when changing their production line. Some production companies use system developers and integrators who create and deliver complete solutions for future production factories. These types of providers is interesting for Flex Hex, as they have a direct access to existing markets in different fields and adapt the product specifically to their customer's demand. Each of the potential customer groups have factors which consequently will have an effect when prioritizing markets and how fast it is possible to enter these markets, thus having a trade-off between economic market potential and market penetration time.

An example of mapping an extract of different potential groups which can use the Flex Hex concept can be found in the table below.

Segments	**Decision key elements**					**For Flex Hex**	
	Customi-zation	Need of flexibility in production	Just in time de-liveries	Stock of finished goods	Development of new tech-nologies	Time to penetrate the market	Turno-ver
Automotive	+++++	+++++	+++++	+++++	>3 years	Long	High
Aviation	+++++	+++++	+++	++	>10 years	Long	High

Railways	+++++	+++++	++	+	>5 years	Long	Middle
SME production	+++	+++++	+++++	+	Short	Short	High
Welding	++	+++	+	+	Short	Short	Middle
Integrator	+++++	++	+++++	+++++	<1 year	Middle	Middle
Developer	+++++	+++++	+++++	+++++	<1 year	Middle	Middle

When looking at Europe there are approximately 22.58 million enterprises; 2.1 million of these mainly operates in the manufacturing industry[2]. Within the manufacturing industry there are 10 different sub-industries and measured in *number of enterprises* the biggest industries are *metal*, *wood and wood products* and *food, beverages and tobacco products,* which is seen in figure 10. But when looked at the number of *operational industrial robots* in each sub-industry more than half of the existing robots are within the *automotive industry* and nearly 14% are within the *plastic and chemical products industry*. When an enterprise has existing operational robots, it can be stated that they are more likely to invest in additional robot solutions, which tells us that even though automotive industry or plastic and chemical product industry do not have the same amount of enterprises, they are segments which is relevant to consider regarding the use of Hexapod as well.

[2] http://ec.europa.eu/eurostat/statistics

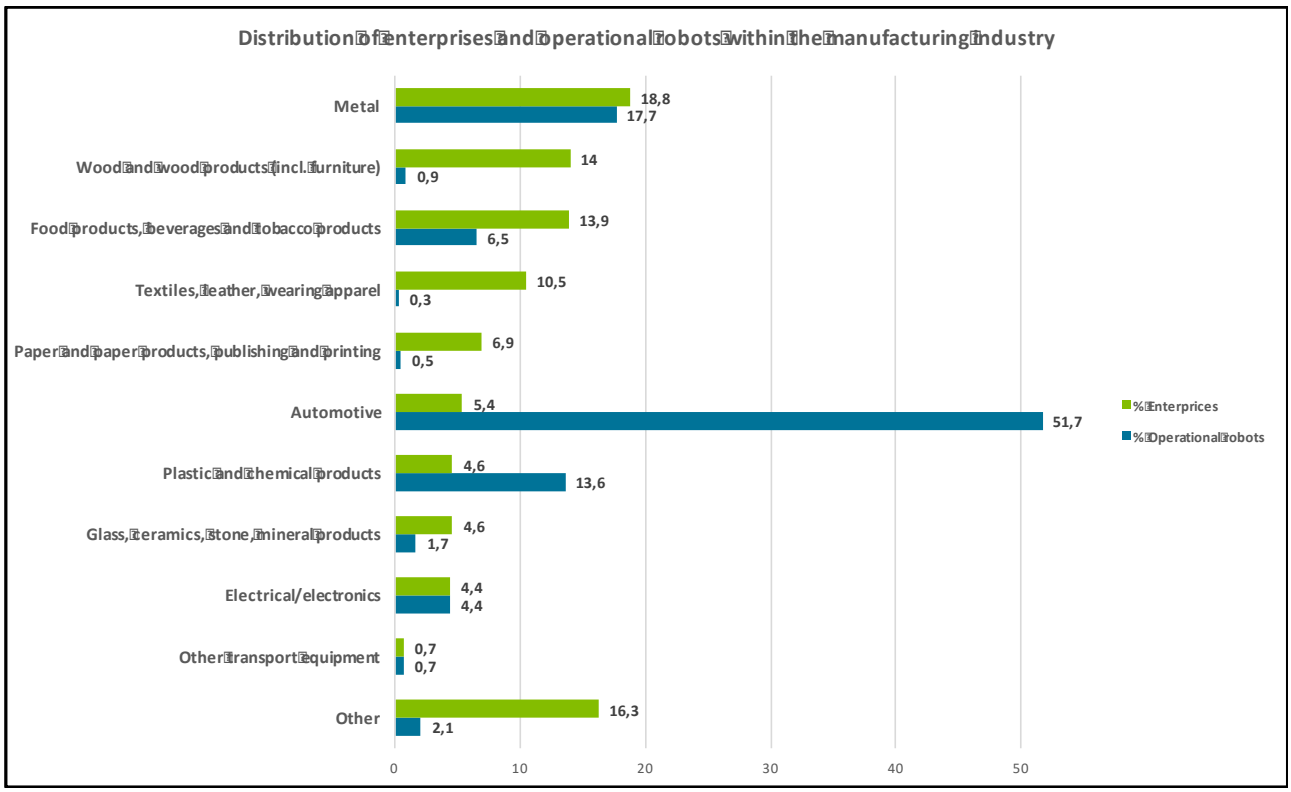


Figure 10: Illustration of enterprises and operational robots within the manufacturing industry

Besides the manufacturing industry the *International Federation of Robotics* (IFR) have made a classification of industries which are; *agriculture, forestry and fishing, mining and quarrying, electricity, gas and water supply, construction, education research and development* and *other unspecified industries*. These are yet unanalysed industries, but by a first glance several of them could be relevant as users of Hexapod. Especially the construction industry which have more than 3.3 million enterprises located in Europe, which is just below 15% of the total number of enterprises in Europe, hence both relevant and potentially profitable. Furthermore, the education research and development industry have an existing number of 3.339 operational robots, why they are likely to invest in new technologies.

Besides looking at the industries, it is relevant to look deeper into industrial applications and how the distribution of robots is here. *IFR* have classified the following industrial applications: *Handling operations/Machine tending, Welding and Soldering, Unspecified, Assembling and Disassembling, Dispensing, Processing* and *Others.* As it is shown in figure 11 more than half of all operational robots in Europe are placed in the industrial applications that do *Handling operations/Machine tending* and 25% are within *Welding and soldering*. As mentioned earlier, when these industrial applications are already using existing robots, they are more likely to invest in additional robot solutions, why there should be put an additional focus on enterprises who especially do these industrial applications.

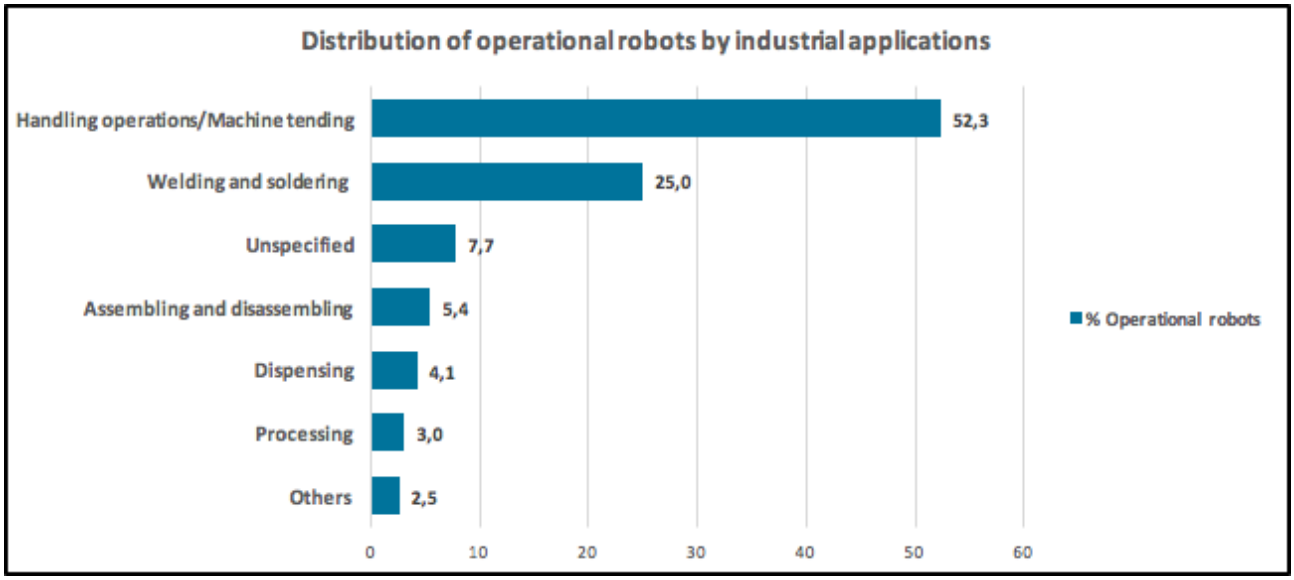


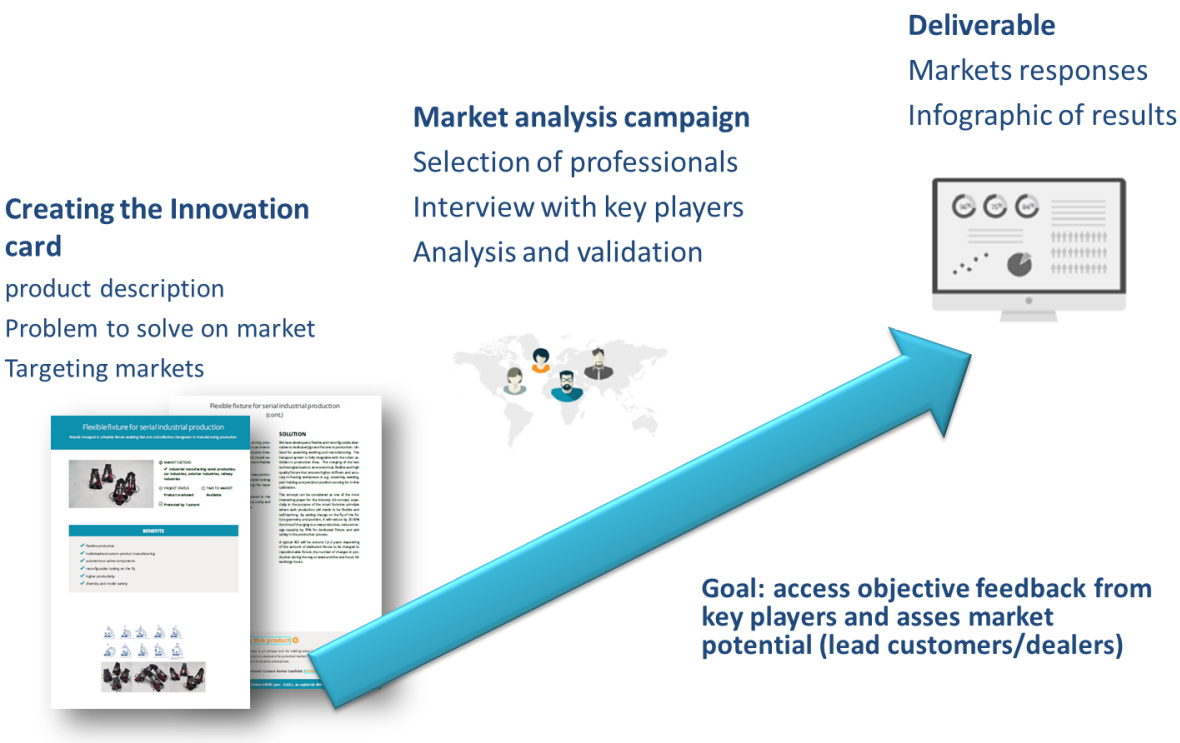
Figure 11: Distribution of operational robots by industrial applications

Based on all these considerations of an estimated number of the total market within Europe can be found. The total market in Europe is calculated to potentially be over **90.000 Hexapods** giving more than **20.000 configurable flexible fixtures**.
By projecting a market share of 1-2% the first 1-3 years and 5-10% the following 3-5 years it will cover the necessary sales needed to secure a positive cash flow for the company within 3 years.

5.2 Market Study

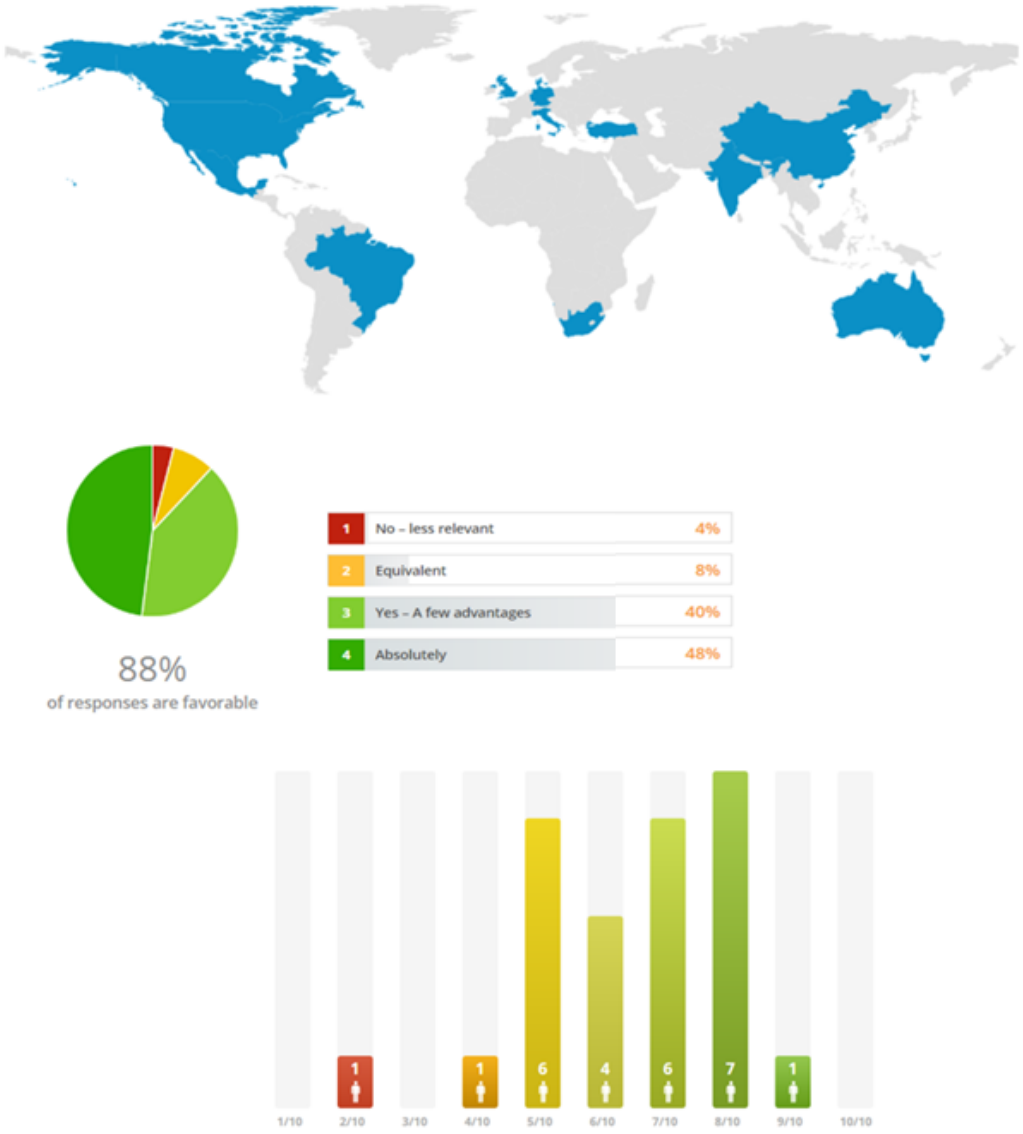
A market study has been started with *United Motion Ideas* (UMI) where innovative ideas can be tested in the market and professionals can give relevant feedback on the innovation who identify themselves as a customer, dealer or follower on the invention.

It works in the following way; an innovation card is created and then sent to professionals who give their feedback:



Preliminary results have given 35 answers from professionals, whereof these primarily comes from professionals in the US, 1/3 from Europe and the remaining coming from the Asian market including Turkey (See figure 12).

We identified very interesting potential customers like: Bila, Faurecia, FCA Italy, Amrikart US, Tata motors, Magna, Dailmer trucks, FNSS, Caetanos Bus, Plustooling. All companies working directly with the automotive business or supplier to it or industries working for automatization of welding or assembly lines.



Figur 12: Market Study by UMI

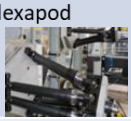
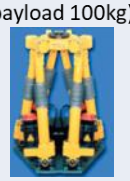
We got 16 who have expressed interest to be either a customer, distributor of the solution or participate to the development of the technology.

The comments on the strength of the innovation cover our goals in terms of recognition of flexibility, rigidity and simplicity where comments on weakness focus on the price and eventual complexity.

It must be pointed that the study is made anonymously and only few technical parameters are available for the persons who have responded to the survey.

5.3 Similar Solutions

With Hexapods:

Company	Type of business	Products	strength	weakness	opportunity
Prodtex SWE/UK company	Development of tooling and fixture Market: mainly aviation	Flexapod 	Already on market, contract with Saab aviation	The Flexapod is not accurate enough due to joint	Prodtex asks FlexHex for an offer Possible Partnership
ABB Worldwide	Automation in car industry	FlexLean 	Well-known company, robotics experience	expensive product with motor driven hexapods, maintenance on actuators	For Flex Hex: Lower price, easy to install and maintain
PI USA	Develops solution for motion and very high accuracy positioning	Hexapod 	Accuracy in positioning (micro) From miniature (1,5kg) to high loads (500kg)	expensive product with motor driven hexapods Suitable for space/mirror application	High price range Require advanced programming , high end user
Fanuc USA/JP	Develops solution for robot welding. Vehicle lift, flexible fixture	Hexapod F-200i (payload 100kg) 	Very stabile system, high rigidity, proven for foundry, harsh environement, high repeatability	expensive and heavy (190kg) with motor driven hexapods to be used with Fanuc robot and software	High price range Require advanced programming , dedicated to Fanuc system (robot, handling tool)

Compared to other systems, the Flex Hex solution offer a simple, ready to use, accurate and stable, easy to maintain and less expensive solution.

Other flexible solution

Combination of Programmable Linear Positioner with 3 axes (PLP):

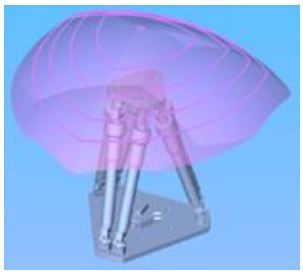
Fig 13: as example

These kinds of systems need bigger workspace than the footprint, the movement is restricted to a predefined geometry, it is not mobile as it need power for working and require a new design for a new shape.

In comparison of all these systems, the advantage of using the hexapod for making a flexible fixture

are:

- No need of redesign the equipment even with a new required geometry
- Less foot prints
- Programable and positional with a robot arm
- Mobile, no need of external energy when lock, only to unlock and re position the fixture
- Scalable from 10kg to 1500kg payloads

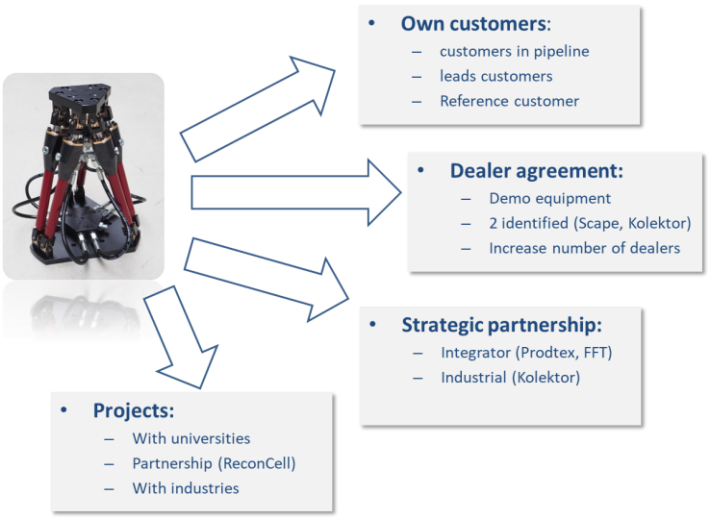


5.4 Go-To-Market Strategy

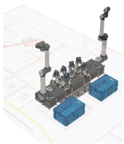
Flex Hex IVS has developed a product which is tested, exist today in 2 size, 10 and 50 kg payload but need to propose to customers a complete solution. This solution must be plug & play or design specifically to the customer or be a part of a complete project in collaboration with integrators.

Flex Hex IVS. intends to go to the market by different approaches, develop the pipeline with lead customers, existing and new customers identified by the market study.

But also enter into agreements with dealers and distributors and strategical partnerships with selected industrial customers. Finally, a close collaboration with universities working on smart factories concept and industry 4.0 would help to make the product more known inside the university and industrial community.



Flex Hex must focus on proposing complete solution to the market, obviously a plug and play solution easy to integrate inside the existing system is the most attractive. To do so, Flex Hex will develop an interface for collaborative robots, type Universal Robot (UR), with a complete package of hexapods, software and hardware giving the possibility for the customer to develop its own flexible fixture. UR+ program is well design for this solution and UR has already shown interest for this collaborative fixture. Then, in collaboration with the customer and its request, Flex Hex want to propose complete solution adapted to the customer. At last, in collaboration with integrator can Flex Hex design, manufacture and deliver specific solution for the needs.

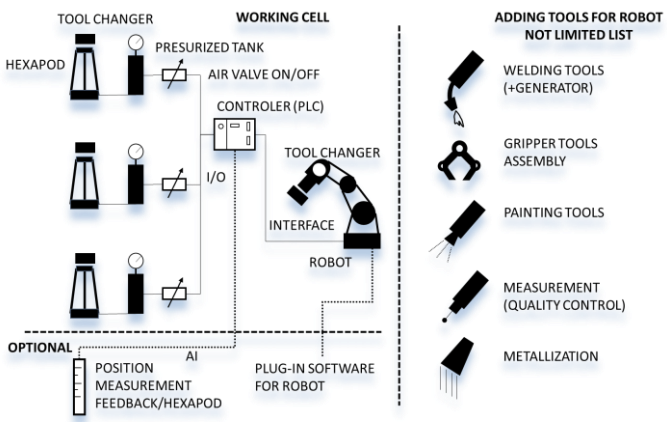
1	Plug & Play	Universal Robot customers Other collaborative robots	Customers who know already the Cobot and have one or several. Want to develop their own flexible fixture **Goal: develop new skills**	
2	Complete fixtures	Adapt to customer request	Customers who want to robotize their production but don´t know how to do it. Delivered with Hexapods, robot arm, interface to production. **Goal : reduce amount of fixtures**	
3	Project sale	To be integrated in existing projects	Targeting integrators and propose flexibility and scalability in design **Goal : for the integrator propose new innovative and less expensive solutions**	

For all customers, the main issues are: **flexibility, reconfigurability, scalability and safety**
The focus is on making the system as easy and simple as possible.

Even if the two existing products are filling a very demanded range, Flex Hex needs to develop a range of products to support this strategy:

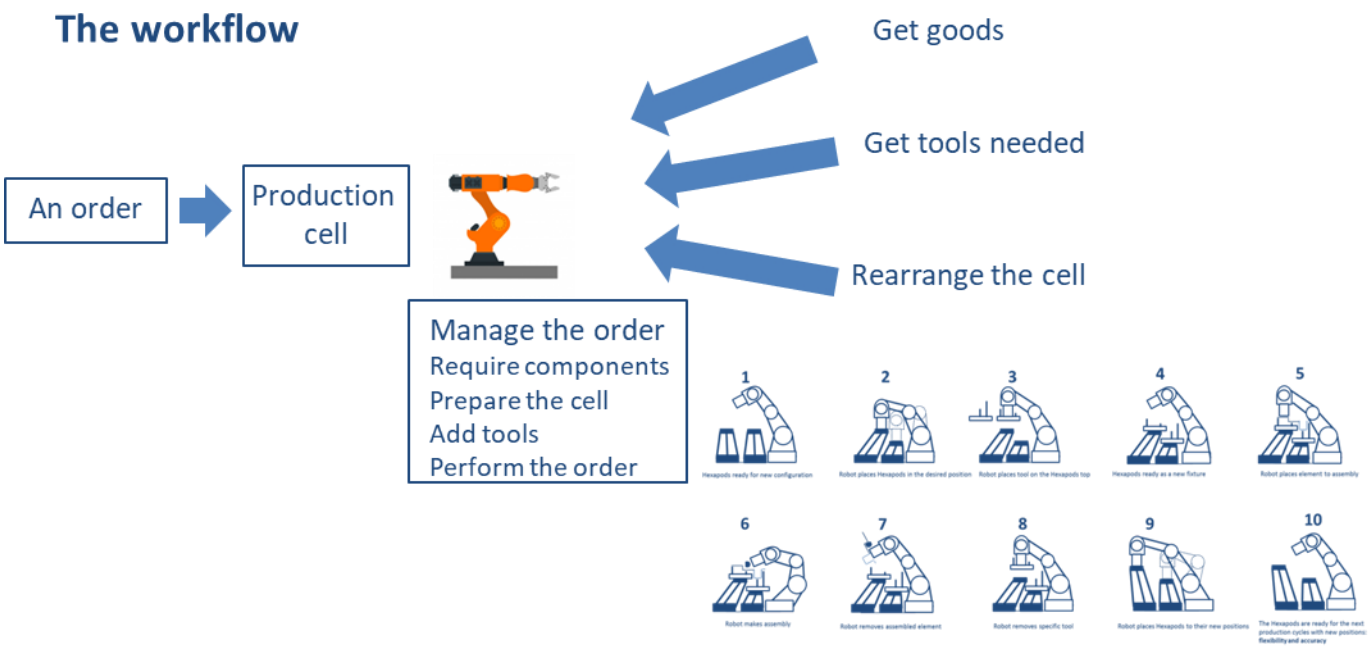
	Product/Payload			
	 5-8 kg (in develop-ment)	 10 kg	 50 kg	< ---- from 100 to 1500 kg ----> (to be developed)
Plug & Play	●	●		
Complete fixtures	●	●	●	
Project sale		●	●	●

For the plug & play and complete fixture, the cell may include the following features:



Remark: Flex Hex will only deliver parts for the working cell, the adding tools for robot must be designed separately depending of the application and leave to the customer.

For the project sale, a design will be proposed according to the needs but based on the working cell standard features. The design will include the complete process allowing the robot to design its own production cell at any time, just by receiving the order.



Flex Hex identifies two channels as high potential and soon customers:

- suppliers of equipment for automotive industries, typically for headlight, interiors where production is in batches (medium volume), just in time and needs support aftersales for 10 years
- companies who need to increase the efficiency and flexibility in their welding process to get new markets and keep competitiveness.

5.5 Customers

As previous works had been initiated with different actors (BMW, Siemens, Edag, Magna), Flex Hex is entering a new dialog with these potential customers but has also developed its own network of potential customers. Further we want to expand the list by new lead customers pointed by the market study.

The market landscape for the Flex Hex solution is large and stretch from automotive industry to aviation and railway, but also includes integrators of automatic solution for industrial production and further to other sectors such as space, defense, transport and alike:

Over 40 companies are interested in the product and concept so far!

6 Customer base, product test and business case

6.1 History of customer base and product tests

During the development of the concept and final product, a prototype has been tested in several use cases with different customers. The results of both the customer base and product test are listed in the table below:

Customer base	Description
FFT	Test of the two sizes of hexapods (10 and 50kg payload) is on going at the Fraunhofer institute in Germany. Results are positives and FFT is now looking on using the hexapods for designing a complete flexible fixture for the aviation industry. **The fixture should in the first project contains 10-12 hexapods**
Easy Tech Poland	Easy Tech is a kind of integrator and proposes complete solution for their customer in Poland for welding and assembly line processes. Easy Tech **has acquired one 10 kg hexapod** for demonstration purpose and presents their solution at different fairs.
DTU (Denmark, mechanical institute)	DTU has been presented for the concept and would like to work further on flexibility in the production process. **DTU has therefore ordered one smaller hexapod** for this purpose (5kg payload). A size which is in development and will be deliver to DTU in few months.
SDU	The new opened Industry 4.0 laboratory is going to be equipped with flexible equipment for production industry. SDU is discussing with Flex Hex for buying Hexapods to feature their laboratory production cell.
Hella	Hella is asking for solution to make their assembly lines for car head light more flexible but also less expensive as Hella uses a lot of money to manufacture specific fixture for different car supplier. **Hella has asked Flex Hex for an offer for 6 hexapods** to equip initially one line for after sale head light.

The result of the above-mentioned product tests with potential end-users showed a strong business case for the Hexapod solution, which is due to the advantages Hexapod offer: flexibility, accuracy, robustness, simplify and less expensive solution.

6.2 Proof of concept/business with Elvez

The company Elvez[3] is producing head car light for several automobile companies. The manufacturing of head car lighting is mainly done manually (two employees produce 2 head lights within 50 seconds) and require specific fixtures for every light to be produce. It takes around 20 min for the operator to make changes in production (change and adjustment of the fixtures) and require a large storage due to the necessity of keeping the possibility of produce the headlight for at least 10 years, even if the production has stopped. Furthermore, automobile company are working just in time and order by batches (200-400 pcs) to reduce their own stock. Typically, the production at Elvez must be changed 2-3 times a day.

example of different car light to be produce on the line and the manual production process

Business Case	With existing dedicated fixture	With flexible fixtures &hexapods
Production change over	20 min	< 5 min
More item to produce	0	> 50.000 headlights/year
employees	2 per cell	1 for 3 cells
storage	All fixtures for 10 years	Not relevant, to be re-programmed

Using a flexible configuration cell with hexapods, Elvez will be able to produce 50.000 more head lights per cell, reduce man hours in the production, lead time between produce and decrease storage of fixed fixtures.

6.3 Comparison between solutions

Below in table 3, three solutions of fixtures have been set up to make comparisons. These solutions are *Non-mechanical fixtures, Motor driven solutions* and the Flex Hex solution, *Hexapod* and is made based on installation of one unit. In the table only, elements which can be measured economically

[3] www.elvez.si/en/

is included, and does not include parameters such as flexibility, stiffness, accuracy and degrees of freedom when using the fixture etc. Neither parameters such as delayed production due to complications is included. Furthermore, it shall be mentioned that the table is based on numbers which resulted from product tests within the automotive industry mentioned above, but are confidential, why it has now been changed into estimations. A graphical comparison can be seen in figure 1.

	Dedicated fixture	Motor driven fixture	Hexapod
Investment cost	Varies, depends on needed materiel resources 5-10.000€	100.000 €	30.000 €
Engineering cost	High	Low	Low
Storage	Need of large storage capacity	Non	Non
Reconfigure time	Depends on workpieces requirements. Between 1 day and 4 weeks.	2-15 seconds	5-30 seconds
Responsive to mechanical collision	Fixture parts or the whole fixture needs to be exchanged or repaired	Serious injuries can occur to the drive system so the whole fixture needs to be changed	Linear parts are the weakest parts of the structure and in the case of the collision they slip and prevent mechanical damage
Shimming	Shimming is performed manually by inserting metal plates	Shimming is performed by a motor driven fixture in the available degrees of freedom	Shimming is performed by an external fixture moving device (robot) in 6 degrees of freedom
Energy dependency	Independent	Dependent	Independent
Energy consumption	Very low	High	Low

Table 1: Comparison between three fixture solutions

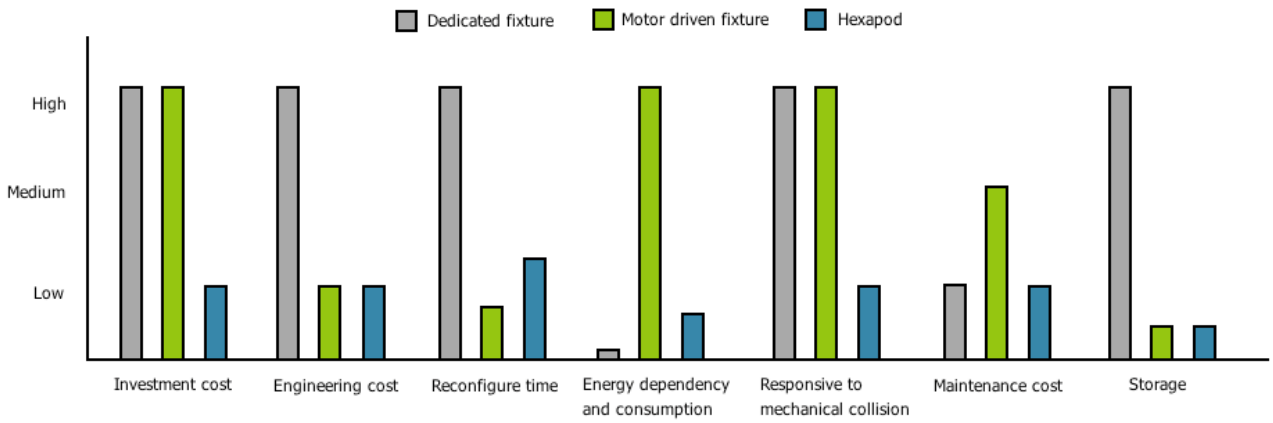


Figure 13: Graphical comparison between three fixture solutions

When looking at investments costs, the costs of the dedicated fixtures varies, because it depends on the needed material and resources to make the fixture, but this is in general expensive. The motor driven solution costs approximately 100.000 € apiece, while the Hexapod costs 7.000€ apiece (see budget). Engineering costs are high when working with dedicated fixtures, while it is low with both motor driven solutions and Hexapod. When talking about time needed to reconfigure, again

the dedicated fixture takes a lot of time depending on the workpiece, but everything between days and up to weeks is common. To reconfigure Hexapod takes between 5-30 seconds, while motor driven fixtures take between 2-15 seconds. The motor driven solutions are thereby a little faster, but not significantly enough to make up for the higher investments cost. Energy dependency and consumption for the dedicated fixture is either very low or non-existing, only when building the fixture energy is needed. The motor driven fixtures are here in high need, since it needs energy to function. The Hexapod needs close to no energy due to the hydraulic system. If a mechanical collision happens fixture parts or the whole fixture must be exchanged or repaired when working with dedicated fixtures. Regarding the motor driven fixtures, it must be changed all together if the injuries are severe. Here the Hexapod is much more resistant to mechanical collision, why it here has a low level of responsiveness. Maintenance cost are estimated to be low for all three solutions but are higher when using the motor driven fixtures. Lastly, there is a big need of storage when using dedicated fixtures, since they need to be put away when not being used, but still saved in case they are needed later. Since both motor driven solutions and Hexapod can be reconfigured there is no need of storage, unless they are needed in a lesser extent depending on the workpiece but will require much less space than the dedicated fixtures.

It can be analysed from the figure that the dedicated fixture will by far be the most expensive and unpredictable solution. The solution depends on many factors which can influence the final cost. What further leaps the eye in the table is the engineering cost and reconfigure time. These parameters require many expensive man-hours which very fast exceeds the costs of the two other solutions, why this solution is discounted.

Further analysing the figure above, investment cost, energy dependency and consumption and responsiveness to mechanical collision are the breaking points between motor driven solutions and Hexapod. The motor driven solution is much costlier to invest in - up to eight times more expensive than Hexapod, have a higher level of energy dependency and consumption, and if a mechanical collision happen it could be very costly since the fixture then have to be exchanged by a new one, thus have higher operational costs and insecurities which could increase these costs further.

6.4 ROI for customers

Customer return on investment depends on the need based on:

- Number of shifts per. day.
- Number of fixed fixtures and installations that can be replaced by a reconfigurable fixture
- Number of employees and time it requires including their salary and staff turnover / training to change from one fixture to another.

In the table below is the calculation of return on investment as an example can be found:

Up-front investment in purchasing Hexapod, compare fixed and reconfigurable fixture price:	10.000 € (fixed fixture) / 30.000 € (reconfigurable fixture with 4 hexapods)
Number of fixed fixtures to be replaced:	From 30 fixed installations to 4 reconfigurable fixtures with Hexapod
Number of changes per. Day of production:	4
Total time spent on change (fixed vs. Hexapod):	1 / 0,2 (Relative time difference during conversion)
Number of employees per. change (fixed vs. hexapod):	2/1 (Proportionate need for conversion)
Yearly savings:	58.215 € (Excluding training or employee turnover expenses)

ROI, year:	2.32

A more detailed ROI calculation has been made by ELVEZ showing a saving of 75% hours in personal to change the dedicated fixtures, 50% of the existing fixtures can be changed by flexible fixtures. The ROI calculation shows a ROI of 3 months in this industry.

Other potential customers have tested our ROI calculator on the web side, which resulted in the following potential ROI:

Customer (self calculated ROI on flexhex-robot.com)	A	B	C	D
application	Assembly	Machining	Assembly	n.a.
Price of dedicated fixture	10.000€	10.000€	2000€	2000€
Hourly rate	12€	20€	10€	50€
Number of fixture to be changed	50	10	10	40
Change/shift	1	2	0,5	5
Savings/year	21.420€	39.125€	23.520€	76.650€
ROI (months)	41	21	18	40

7 Organizational strategy and plan

Flex Hex IVS. arises from a cooperation between Igor Kovac, Blue Ocean Robotics and ELESTRA, while the CEO Laurent Marquis have been added as a valuable resource to the business:

- **Igor Kovac,** Prof. PhD, is personal research focus is on coordinating measuring arms, robot-aided reconfiguration, sustainable machinery integration, automation in construction and factories of the future (FoF). His career started at the Jožef Stefan Institute, Slovenia, continued at the University of Maribor, Slovenia, Graz University of Technology, Austria and Vienna University of Technology, Austria. He has taken this research and has in collaboration with industries used this to implement robots in production. Igor Kovac is the inventor behind the Hexapod. He found that a flexible, reconfigurable and cheap system for fixture-based production could be a way of decreasing cost production and lead time and invented the Hexapod. He has worked on the solution for more than 15 years, making series of test with industrial actors in the automotive and railway industries. He is further conducting all the tests and developments of the Hexapod.
- **ELESTRA** is a company with a 40-year experience in manufacturing. They provide integral high-quality solutions in design, development, production and assembly of injection products and metal processing. ELESTRA is a well driven family company lead by the manager, Miha Vrhovec who has a PhD in Robotics from the Stefan Institute. ELESTRA has already built and delivered 6 Hexapods for the *ReconCell European* project. The company has a capacity of producing around 100 hexapods a year. Investments in machines and storage then needs to be done in the future to increase the capacity.

- **Laurent Marquis, CEO** has joined the company upon incorporation both as a CEO but also as an investor. His investment is 500.000, - DKK to finance the company with seed money prior to completion of the present investor round. His background is former CEO of the company Wavestar A/S, a company initiated by the Clausen family (the Danfoss family) for developing renewable energy from ocean waves. Prior to joining the Wavestar company, Mr. Laurent Marquis has held leading position in Danish companies like DISA A/S and Icopal A/S and brings in a solid industrial background as well as a strong management history.

All parties will be involved in research and development of the Hexapod product and public funding. The CEO, Laurent Marquis, is in charge of organizational build-up and hiring people, while also handling daily management. Regarding manufacturing, assembly and overall production of Hexapods, ELESTRA will be in charge and furthermore do delivery and service of sold Hexapods. Moreover, there is a need of a financial investor.

Igor Kovac has a 45% ownership, ELESTRA and Marlauto Aps (Laurent Marquis) have both 27,5% ownership.

Blue Ocean Robotics involvement in the company was not considered valuable enough by the other owners and an agreement was signed between the owners so Blue Ocean Robotics withdraws from the project.

Below in figure 16, an illustration of the actual stakeholders in Flex Hex IVS.:

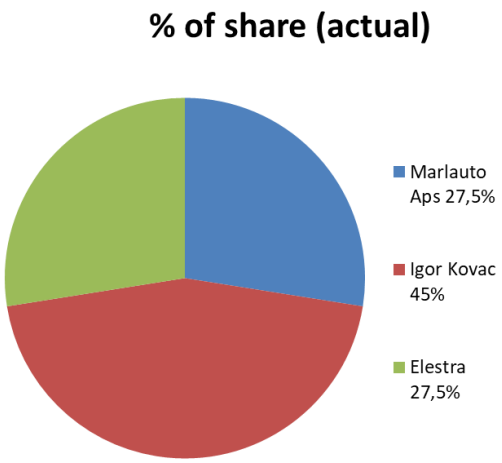


Figure 14: Illustration of the stakeholders in Flex Hex IVS.

7.1 Board of directors

Flex Hex IVS.'s board of directors includes Igor Kovac, CEO Laurent Marquis, Miha Vrhovec, CEO of ELESTRA. The new investor will be invited to join the board.

7.2 Company Organisation and Employment Perspective

Flex Hex IVS. intends to develop its activities in balance with new employment in the company during the next years. The priority is placed on sales and development in the first round and then in service, after sales and expedition in the second round.

Markets in south of Europe like France, Italy, Spain and Portugal seems promising and will require a better implantation of Flex Hex in these regions. We estimate that a sales office in France will be able to support this area:

The development of employment will principally be in Denmark for the R&D and sales but perspective for production facilities are open when the quantity of pieces to produce will exceed the production capacity at the Company ELESTRA:

New employees	2019	2020	2021	2022	2023
CEO (exits)	1				
Sales	1		1		
R&D engineer		1		1	1
Technician					1
Service					
Adm. legacy		0,5		0,5	
Total employees					
existing	1	2	3,5	4,5	6
New	1	1,5	1	1,5	2
Total	2	3,5	4,5	6	8

8 Financial plan and budgets

The following budget and calculations for Flex Hex IVS. are preliminary and allow for changes in the newly established company. To calculate the total income of sales, the below price calculations for the smallest Hexapod have been used:

Hexapod price calculation		
	<100 units	**>100 units**
Costs	€3,794	€3,080
Internal net profit (30% / 100%)	€1,138	€3,080
Sales partner (off sales price excl. install)	€870	€840
Market price	€5,802	€7,000

The market price is made for below and above 100 units produced and differ in the direct production costs, internal contribution margin and sales partner share. The production costs include material, manufacturing and assembly for one Hexapod, the material and manufacturing of patented cardan joints (passive linear elements), clamping sleeves (incl. 10 % discount) and pressure transformer (incl. 4 % discount). When the first 100 units are produced, the different costs will be reduced with 20-30 % and include a 12% ELESTRA production overhead instead. To calculate the final market price, 30% internal net profit exist for producing below 100 unit and 100% when production reaches more than 100 units. The sales partner includes an amount of 15% for first 100 units and then 12% for the following units of the total market price.

8.1 Strategic value

8.1.1 Assumptions for cash-flow

Discounting cash flows is the best way to assess the potential value of the Flex Hex Company, since it incorporates all the consequences of future development and strategic choices. Key hypotheses are as follows:

- Necessity to establish a pool of competencies including a robot engineer, a mechanical engineer, a service worker and salesmen. The CEO will be assisted by a part time administrative person
- Establishment of test facilities at the main office for development purpose (positioning system, vision system) and training of operator.
- The salesmen will have to travel around Europe to promote and prepare projects with selected customer
- The mechanical and robot engineer will work on designing and prepare production design for projects at customer

8.1.2 Discounting rate

The first phase of development has been validated with the test of first prototypes within different industries especially car, railway and aircraft industries. The results were according to the expectation and it has delivered one 200kg Payload Hexapod to Siemens Railway in Austria, one 50 kg Pay

load Hexapod to BMW and FFT/Fraunhofer and 4x10 kg Hexapod for the Reconcell[4] project. Few orders have been proceeded for the new company.

Regarding the WACC, it is more appropriate to consider Flex Hex in a private equity/ business angel phase with a cost of capital around 35%[5] for early start-up companies. Eventually, as risk decreases along with proofs of efficiency, WACC decreases to 20%, in 2022.

If we used a cash flow fade approach to Terminal Value estimation, over 5 years, we would be left with **a Terminal Value comprise between €10M representing 10,9 x EBITDA[6] using the best multiple of EBITA and €5,3M using the median multiple value of 5,5 x EBITDA[7].** By discounting the terminal value with the discounting factor of the whole 5 first years' period, **we obtain the Flex Hex value comprise between €2,8M in 2019 (best mutilple) and €1,4M (median multiple)**.

In the table below please find the preliminary budget for Flex Hex IVS.for the next 5 years:

	2019	2020	2021	2022	2023
number of hexapods sold	24	60	90	180	468
Net sales+ service	€ 44.340	€ 217.217	€ 325.826	€ 651.652	€ 1.694.296
Royalties JSI	€ 139	€ 832	€ 1.249	€ 2.791	€ 7.257
staff cost	€ 99.000	€ 314.400	€ 430.920	€ 560.952	€ 725.149
development&capacity cost	€ 22.040	€ 67.100	€ 68.522	€ 74.011	€ 91.187
total cost	€ 121.040	€ 381.500	€ 499.442	€ 634.963	€ 816.335
results	€ -76.840	€ -165.115	€ -174.865	€ 13.898	€ 870.705
Acc.results	€ -76.840	€ -241.954	€ -416.819	€ -402.921	€ 467.784
income tax	€0	€0	€0	€0	€155.928
monthly cashflow change	€ -78.145	€ -222.902	€ -207.982	€ -52.883	€ 540.668
working capital	€ 920	€ 38.239	€ 71.356	€ 171.254	€ 445.261
change in working capital	€ 920	€ 37.319	€ 33.117	€ 99.898	€ 274.007
investment					
early investment (2018)	€ 65.000				
investment	€ 250.000	€ 300.000	€ -	€ -	
capital increase (2018)	€ 7.000	€ -	€ -	€ -	
Innobooster (2018)	€ 28.864	€ -			
Operation 2018	€ -87.000				
total	€ 263.864	€ 300.000	€ -	€ -	€ -
cash position	€ 185.719	€ 262.817	€ 54.835	€ 1.953	€ 542.621
employees	2	3,5	4,5	6	8

[4] http://www.reconcell.eu/

[5] *This figure is based on the PEPPERDINE PRIVATE CAPITAL MARKETS PROJECT | 2016 CAPITAL MARKETS REPORT, median expected return of Venture Capital Firms, for start-ups and early stage (Table 1)*

[6] This figure is based on the ROBO global presentation report from January 2017

[7] *PEPPERDINE PRIVATE CAPITAL MARKETS PROJECT | 2016 operational and assessment characteristics*

8.2 Financial needs

8.2.1 Public funding

To prepare the development of the Flex Hex range of product (scaling, positioning system, vision system and industrial application), Flex Hex has in August 2017 received funding from Innovation Fund[8], the support is of 497.600 DKK (66.350€), the self-financing is 1.057.400 DKK (141.000€).

8.2.2 Private funding

The total capital needed is estimated to be €550.000 for the next 2 years but the next 12 months will be crucial as it will confirm the ability to establish a valuable market with sales objective of more than 60 hexapods or generate revenue over €217.000.

Flex Hex intends to raise €250.000 of private equity to ensure a balanced cash-flow statement for the next 12 months and €300.000 again for the following next 12 months. This capital will ensure the company to establish a market and sales to customers including sales of unit for testing to a favorable price. A fund-raising process has already been initiated to cover these financial needs.

By this amount the investors will get 25,8% of the company share:

Valuation and new investor share	
WACC	35%
Best EBIT A ROBO report	10,9
Median EBIT A Pepperdine	5,5
Post-money	€970.000
Investor	€250.000
Investor share	**25,8%**

9 Exit strategy

From the cap table summary listed below several exit opportunities have been identified as relevant for the investors. In general, it is projected that within 4-6 years Flex Hex IVS. will be an interesting case for considerations of a trade sale and will be actively pursued by the owner's hereafter. With a strong product and build-up of an initial market with a strong network of distributors and sales partners and long list of customers domestically and internationally, the valuation of Flex Hex IVS. is expected to be between 1,3 to 1,5 M€ after the initial five years. Depending on the market penetration and the pace of building a business around Flex Hex IVS., another exit opportunity is a buy-out of the institutional investor, that can be based either on a buy-out from the other owners or an earn-out model based on Flex Hex IVS. buying up shares from the investor with a negotiated mark-up on each share. The conditions and terms for such a buy-out model will depend on negotiations at that time and cannot be specified at present.

[8] The innovation fund is supporting emergent company with the Innobooster funding process: https://innovationsfonden.dk/da/investeringstype/innobooster

A summary of partners and co-owners is given based on a post-money valuation of 0,97M€:

	Investment	Ownership	Exit strategy
Igor Kovac	Robot-concept, research and development, chairman of the board	26,3%	Trade-sale or buy-out
ELESTRA	Production and assembly, board position	16,1%	Trade-sale or buy-out
Marlauto ApS	Early investment in form of convertible loan to the company (to be converted), board position	31,8%	Trade-sale or buy-out
Investor	€250.000, board position	25,8%	Trade-sale or buy-out
Incentive programme management		TBD	