D7.2 Conceptual design and integration guidelines

Fresh and processed food production line

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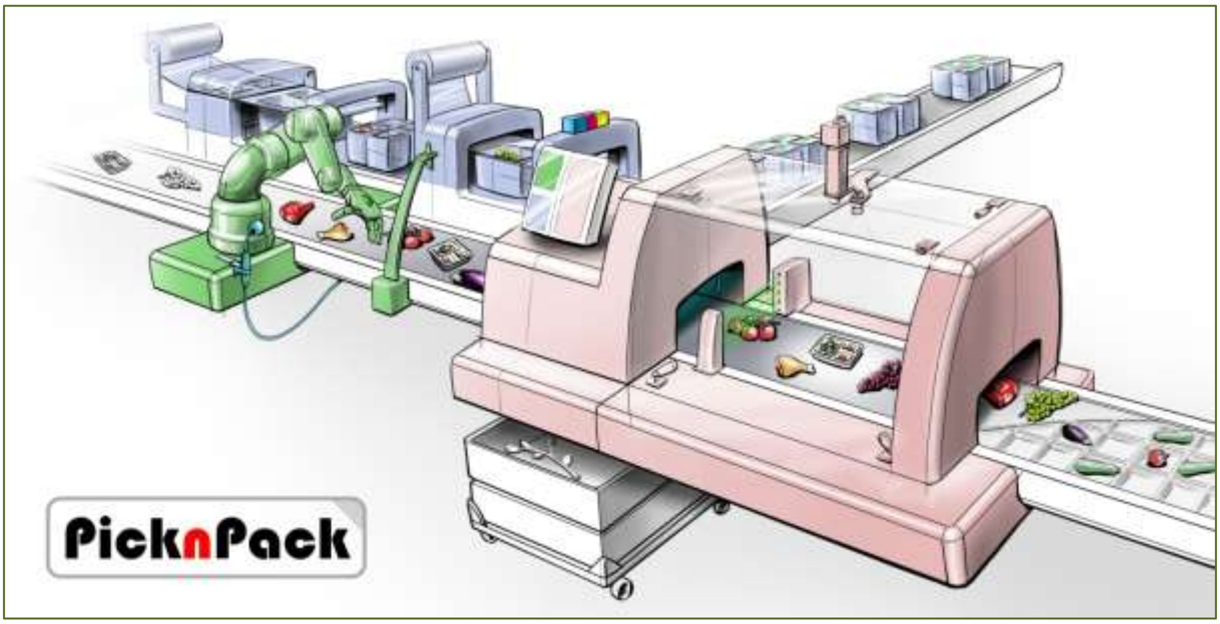

Flexible robotic systems for automated adaptive packaging of fresh and processed food products

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Dissemination level		
PU	Public	X
PR	Restricted to other programme participants (including the EC Services)	
RE	Restricted to a group specified by the consortium (including the EC Services)	
CO	Confidential, only for members of the consortium (including the EC Services)	

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1 Introduction

This report describes the conceptual design and integration guidelines for the integrated fresh and processed food production line to be built within Work Package 7. The integrated line will be used as a demonstrator at a fresh food packing station, as well as for demonstrations to ready meal industry.

In the previous deliverable D7.1 the first iteration of setting requirements for the demonstration lines had started. Here we describe the second iteration in integration and development. We want to improve the overall outcome of the project, as long as the rolling list of requirements and objectives is shared and communicated well with all partners, to ensure proper engagement with the design objectives and requirements.

On the 3rd of July we held a workshop meeting in Leuven, Belgium where a lot of partners attended. The main points discussed during the Leuven meeting were the robotic tasks in ready meal production and how these should be integrated into the PicknPack demonstrator line. We decided to work on cooked meat grasping, scooping of vegetables and dispensing for sauce and/or mashed potato. These developments will facilitate the production of three component meals and of pies.

On the 17th of September a workshop was organised in Montpellier, France. This meeting was to further work on the tasks of WP2 and WP5 about software integration and the robotic workcell design and tasks description. This deliverable includes the discussions and directions from that workshop as well.

On the 24th of September we were able to visit a Dutch ready meal manufacturing company. Here we discussed the same topics as we did during the visits to the companies in England in June. We asked which were the bottlenecks in their production lines and what were limiting factors. We saw their pizza manufacturing line as well. A lot of manual labour was involved, because small batches of pizza were produced. For the production of pizza scooping and grasping is relevant as well, especially because some ingredients are applied in low volume and not weighed, and need to be spread in a proper way over the pizza bottom layer.

2 Demonstrator applications

In this chapter we describe the two demonstrator applications. Firstly the fresh food application is described. Secondly, the ready meal application is described. One of the topics that has not been decided upon, though is very relevant for setting the limits and boundaries of the demonstrators is where the final demonstrations will take place.

For vine fruit this will be at the fruit packing stations, they will provide for floor space and materials to be handled by the PicknPack production line. Initial testing can take place at Wageningen UR.
For ready meals it is harder to demonstrate at real production facilities due to much stricter hygienic design and operation constraints. We propose to test at facilities of AZTI and Lincoln University.

Though the final places to demonstrate will have to be decided during one of the meetings planned ahead.

2.1 Fresh food application

This section describes the specifications of the fresh food application and the input and output relations of each sub module.

Main Task: The fresh food application will demonstrate packaging the following products:

- Vine Tomatoes (types: regular & alternative)
- Grapes (color: white/green)

As described in Deliverable 7.1, these products are either presented to the demonstrator in harvest bins (Vine Tomatoes) or delivered individually on a conveyor belt (Grapes) . A pick & place module will empty these bins onto a conveyer belt with one product at a time. The product is then transported to a sensing module, which assess the quality of the product. If the quality is sufficient, the product is either picked and placed into a package from the conveyor belt, or is discarded for other use or as waste product. In Figure 1 an overview of this process is sketched.

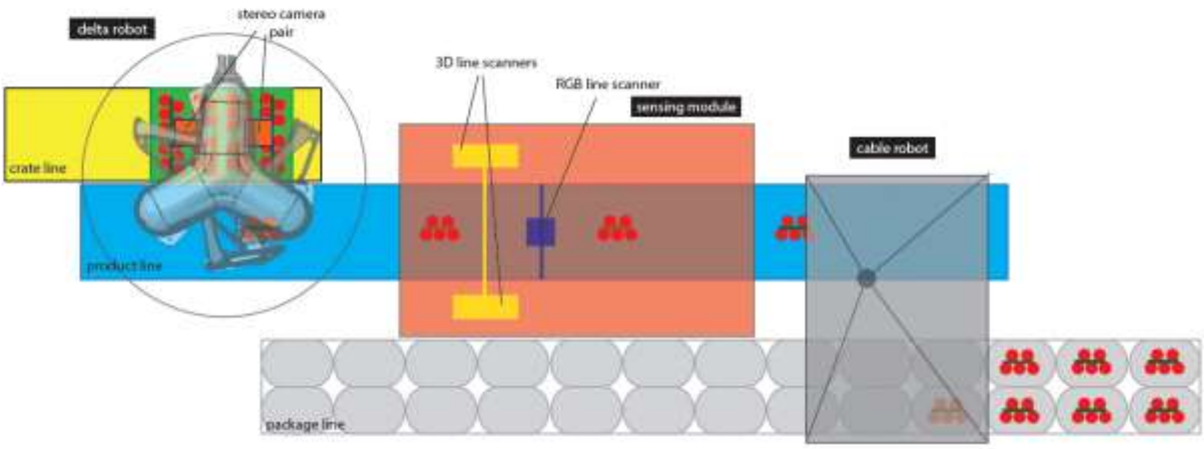


Figure 1: Schematic overview of the modules in the fresh food application line. Input is delivered at the top left. Packaged output leaves the line at the bottom right.

For this application, 4 sub modules can be distinguished:

- Pick & Place Source: from harvesting bin onto conveyor belt.
- Sensing Module.
- Pick & Place Target: from conveyor belt into package.
- Packaging Module.

2.1.1 Fresh Food Application - Pick & Place Source Task

The task of this module is to pick and place individual fresh food product from a source, either i) a harvesting bin or ii) a conveyor belt onto a target conveyor belt.

2.1.2 Fresh Food Application - Pick & Place Source Inputs

The input of this application differs with the type of product to be packaged. In this section we will define what input can be expected per product. This input is based on the current industrial standards. However, other work packages can provide further specifications or constraints on this input if required. In that case, a change of the input should be discussed with the industry in order to check on the feasibility of the change.

Vine Tomatoes – General Specifications

Tomatoes will be delivered in harvesting bins to the application as input.

Vine Tomatoes – Harvesting Bin

- Type	:	Euro Pool System - Middle
- Weight	:	1600 grams
- External Dimensions of crate	:	length 600 mm width 400 mm height 179 mm
- Internal Dimensions of crate	:	length 566 mm width 366 mm height 164 mm
- Tomato Package Dimension	:	length 180 mm width 120 mm height 90 mm
- Tomato Types	:	Regular Alternative

Vine Tomatoes – Regular

(note that the tray underneath is not part of the input) :

Color	:	Colour can range from green, yellow, orange to red.
Product distribution	:	Two layers of vine tomatoes, separated with a white paper sheet. Each layer contains around 2x4 trusses. Each truss generally contains 5 or 6 tomatoes. Tomatoes may overlap. See image below for an example situation.

Vine Tomatoes – Alternative

(note that the tray underneath is not part of the input) :

Color	:	Color can range from green, yellow, orange to red.
Product distribution	:	Two layers of vine tomatoes, separated with a white paper sheet. Each layer contains around 3x6 trusses. Each truss generally contains 5 or 6 tomatoes. Tomatoes may overlap. Example situation is similar to the product distribution image in the Vine Tomatoes – Regular.

Grapes – General Specifications

Grapes will be to the application individually on a conveyor belt.

Grape Type	:	white/green grapes
Diameter grape	:	2.5 cm
Truss dimensions	:	approx. 20x10 cm
Color	:	white/green
Product distribution	:	Single product. Orientation may differ.

maximum package output dimensions	:	length 210 mm
		width 210 mm
		height 100 mm

2.1.3 Fresh Food Application - Pick & Place Source Outputs

Organic output	:	A single catch weight product (1 tomato truss / 1 grape truss) placed onto the conveyor belt. Orientation will be fixed, but is not yet decided upon. Should be discussed with the sensing work package. Placed orientation is the input for the sensing module.

2.1.4 Fresh Food Application - Sensing Module Task

The main task of the sensing module is to derive all kinds of product information, whilst not physically manipulating the input product.

2.1.5 Fresh Food Application - Sensing Module Inputs and Outputs

The sensing module receives the output of the *'Pick & Place Source'* module. Hence this can be a truss of grapes or one of the two types of vine tomatoes. No physical manipulation will be performed, so the output of this module will be equal to its inputs.

2.1.6 Fresh Food Application Pick & Place Target Task

The main task of the Pick and Place Target module is to pick products sequentially from the conveyor belt and place each product into a separate packaging tray.

2.1.7 Fresh Food Application - Pick & Place Target Inputs and Outputs

The 'Pick & Place Target' module will receive the output of the Sensing Module. Hence this can be a truss of grapes or one of the two types of vine tomatoes.

2.1.8 Fresh Food Application - Packaging Module Task

The main tasks of the packaging module is to i) create packages to be filled with fresh food products, to ii) seal the packages, ii) label them and iv) perforate the seal.

2.1.9 Fresh Food Application - Packaging Module Inputs

The packaging module has 2 main inputs: organic input and packaging input.
The organic input is received from the 'Pick and Place Target' output. Hence this can be a truss of grapes or one of the two types of vine tomatoes.
The material input is a roll of plastics that is needed to form the packaging trays. A second input roll of plastics is to be used in the packaging module for sealing.

2.1.10 Fresh Food Application - Packaging Module Outputs

The output of the packaging module is a packaged organic product, placed in a tray that is sealed and printed. The packages dimensions shall not exceed:

maximum package output dimensions:	length	210 mm
	width	210 mm
	height	100 mm

2.2 Ready Meal Application

This section describes the specifications of the ready meal application and the input and output relations of each sub module.

Main Task: The fresh food application will demonstrate packaging of ready meals; which will consist of three components: a meat component, a carbohydrate component and vegetables. This could for example be a combination of chicken breast, carrots and peas or beans, and mashed potato.

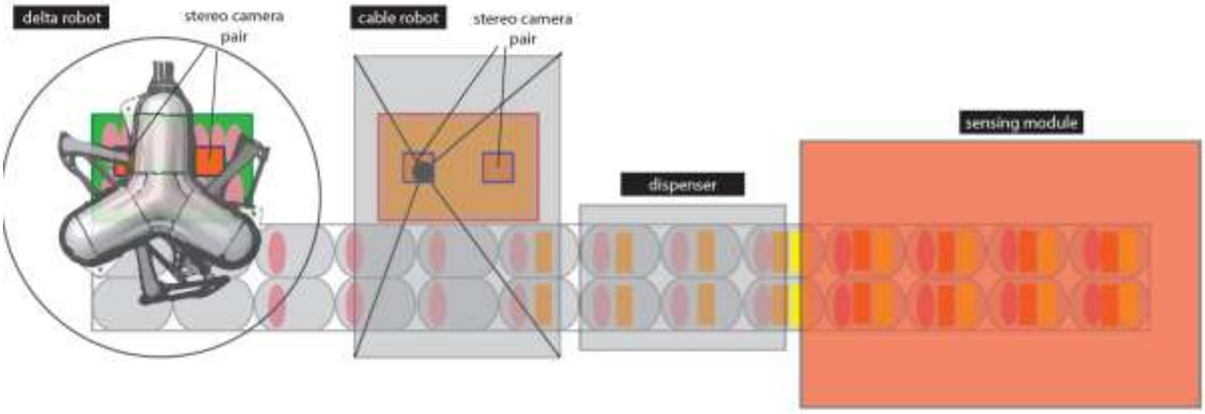


Figure 2: Schematic overview of the modules in the ready meal application line. Input is delivered at the left. Packaged output leaves the line at the right.

For this application, 5 sub modules can be distinguished:

- Pick & Place Source Delta: from source bin onto packaging tray with delta robot
- Pick & Place Source Cable: from source bin onto packaging tray with cable robot.
- Dispensing Module.
- Sensing Module.
- Packaging Module.

2.2.1 Ready Meal Application - Packaging Tasks

The main tasks of the packaging module is to i) create packages to be filled with a 3 component meal, to ii) seal the packages, ii) label them and iv) perforate the seal. Furthermore, in this application the module will also be responsible for transporting the packages through all modules of the line.

2.2.2 Ready Meal Application - Packaging Module Input

The material input is a roll of plastics that is needed to form the packaging trays. A second input roll of plastics is to be used in the packaging module for sealing.

2.2.3 Ready Meal Application - Packaging Module Output

Two outputs can be distinguished from the '*Packaging'* module. The first output is a stream of empty food container trays, 2 in parallel, at the beginning of the line. The second is at the end of the line, where a stream of filled food containers, 2 in parallel, are sealed.

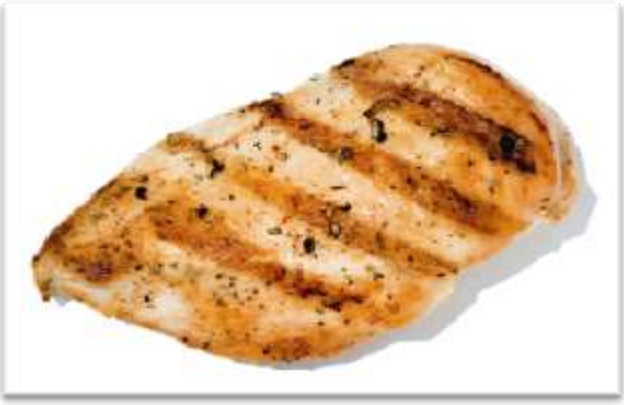
2.2.4 Ready Meal Application - Pick & Place Source Delta Task

The 'Pick & Place Source Delta' module has the main task of picking the meat component from a source bin into a pre-determined fixed part of an empty food container.

2.2.5 Ready Meal Application - Pick & Place Source Delta Inputs

The input for the first source bin into the packaging tray can consist out the following food products. Furthermore, the empty food container trays enter the module in parallel.

Cooked Chicken Breasts



Example product:

Product dimensions	:	maximum length	175 mm
		maximum width	100 mm
		maximum height	75 mm
Color	:	meat colour	
Amount per portion	:	1 pc.	
Product distribution	:	Chicken breasts will be randomly distributed on a pile inside crate.	

2.2.6 Ready Meal Application - Pick & Place Source Delta Outputs

The output of the module are two trays in parallel in which both a single meat product (Cooked Chicken Breast) is placed directly into a fixed part of one of the pre-made food containers by the Packaging module. Note that there are no compartments present in the package tray.

2.2.7 Ready Meal Application - Pick & Place Source Cable Task

The 'Pick & Place Source Delta' module has the main task of picking a vegetable component from a source bin into a pre-determined fixed part of an semi-filled food container.

2.2.8 Ready Meal Application - Pick & Place Source Cable Inputs

The input of the Pick & Place Source Cable module is the output of the Pick & Place Source Delta module: a set of parallel food containers in which a single meat product (Cooked Chicken Breast) has been placed. Furthermore, the additional vegetable input to for the cable robot to be picked and placed can be of the following types:

Peas:

Example product:

Color	:	Green
Amount per portion	:	approx 100 grams
Product distribution	:	Peas will be randomly distributed on a pile inside crate.

Carrots:

Example product:

Product dimensions	:	no length and width defined
Color	:	Orange
Amount per portion	:	100 grams
Product distribution	:	Carrots will be randomly distributed on a pile inside crate.

2.2.9 Ready Meal Application - Pick & Place Source Cable Outputs

The output of the module consists of two trays in parallel of which one part is filled with meat (Cooked Chicken Breast) and of which another part is filled with vegetables (Carrots or Peas). Both the meat and vegetable products are placed directly into determined parts of one of the pre-made food containers by the Packaging module. Note that there are no separate compartments present in the package tray.

2.2.10 Ready Meal Application - Dispenser Module Task

The dispenser module has the main task of dispensing a carbohydrate into a pre-determined fixed part of an semi-filled food container. An example of a dispenser that could be used within PicknPack is shown in the following figure:

Dispenser from Turbo Systems ltd (http://www.turbo-systems.com)

2.2.11 Ready Meal Application - Dispenser Module Inputs

The input to this module is the output of the *'Pick & Place Source Cable'* module's output; two food containers with a meat and vegetable product. Furthermore, the additional input to the dispenser is a carbohydrate product (*'Mashed Potatoes'*).

2.2.12 Ready Meal Application - Dispenser Module Output

The dispenser module dispenses the carbohydrate product (*'Mashed Potatoes'*) in the remainder part of both the food containers.

2.2.13 Ready Meal Application - Sensing Module Task

The main task of the sensing module is to derive all kinds of product information, whilst not physically manipulating the input product.

2.2.14 Ready Meal Application - Sensing Module Inputs

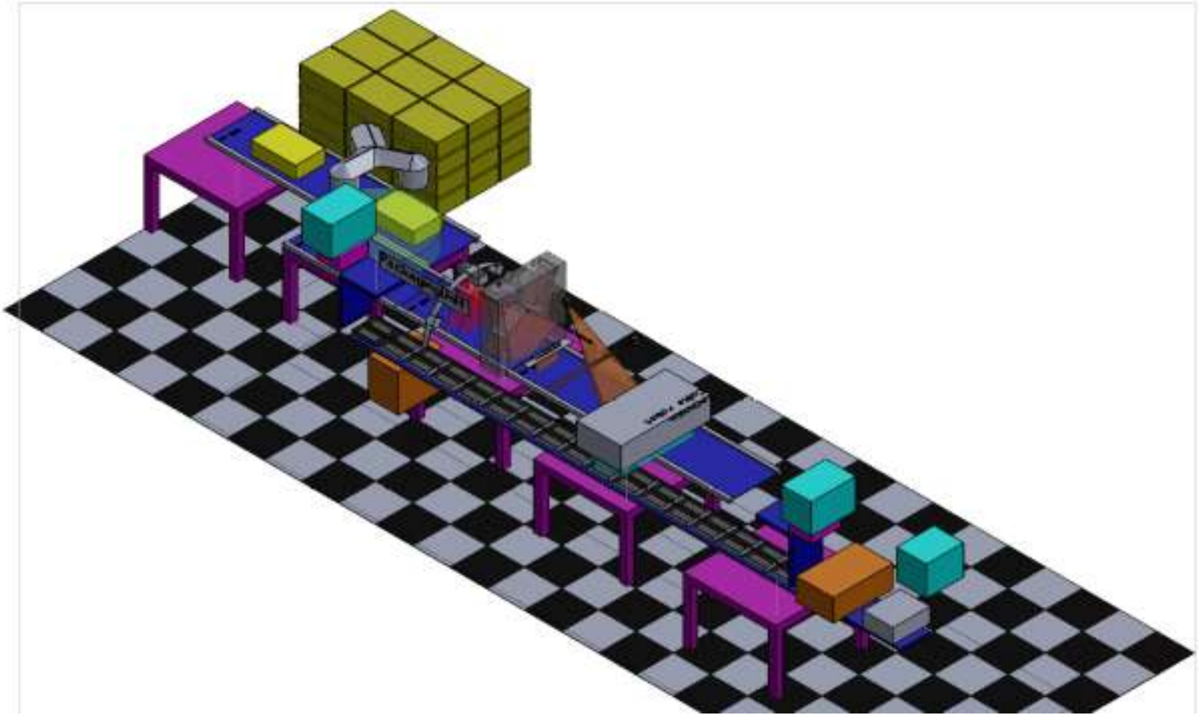
The input to this module is the output of the *'Dispenser'* module's output; two food containers with a meat, vegetable and carbohydrate product.

2.2.15 Ready Meal Application - Sensing Module Output

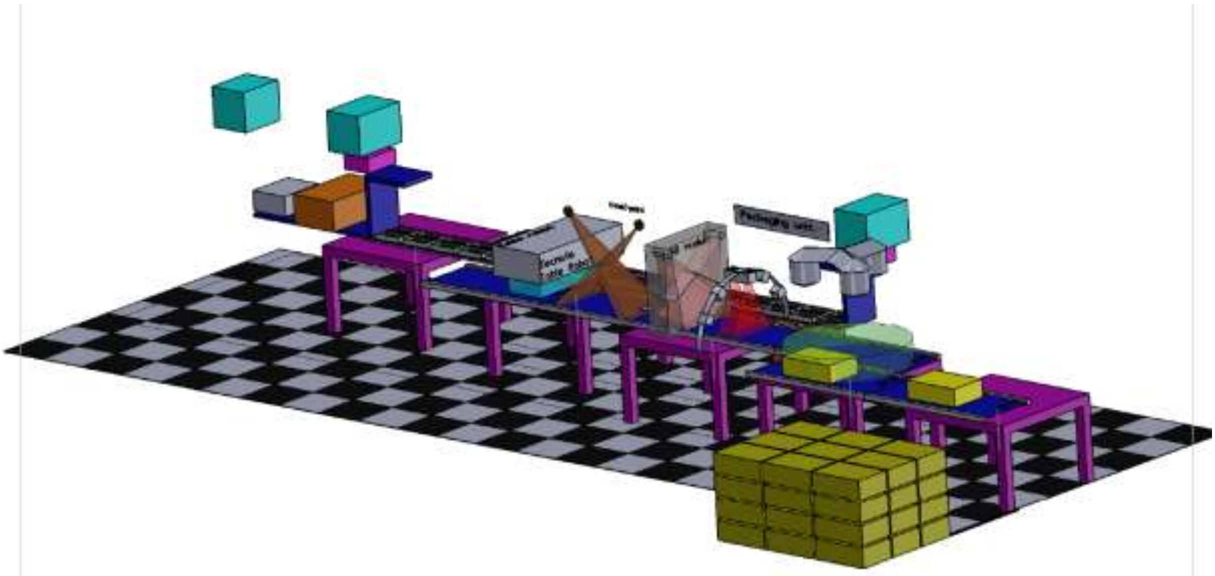
The input remains unchanged, hence the output is equal to the input: two food containers with a meat, vegetable and carbohydrate product.

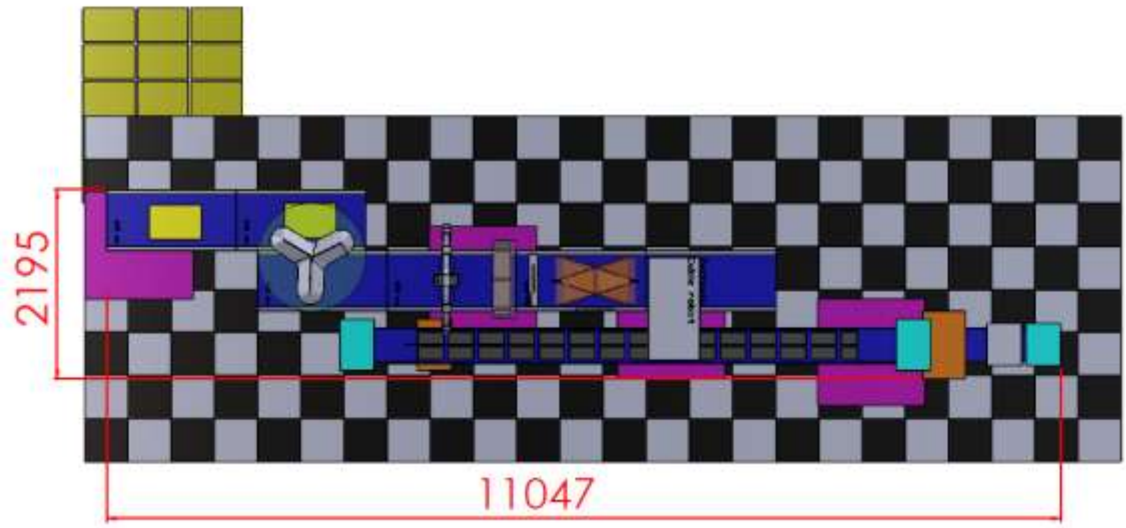
2.3 Detailed sketches of the line layouts

Fresh food line view 1

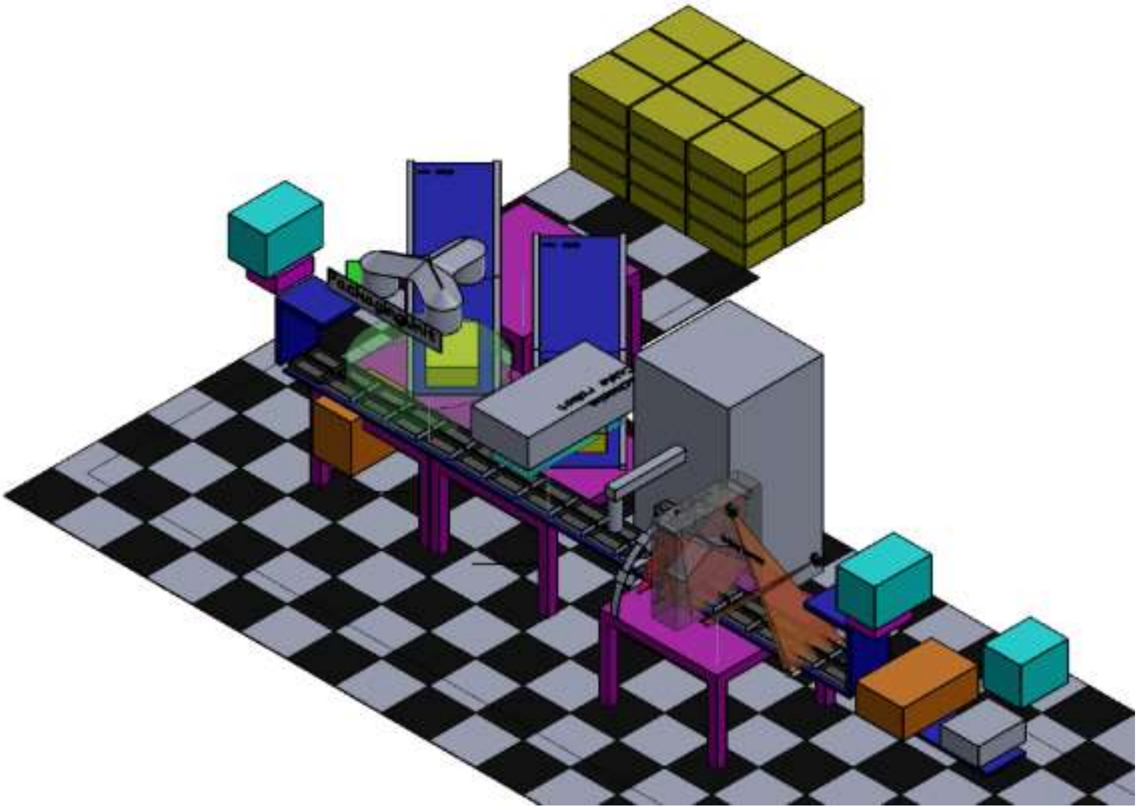


Fresh food line view 2

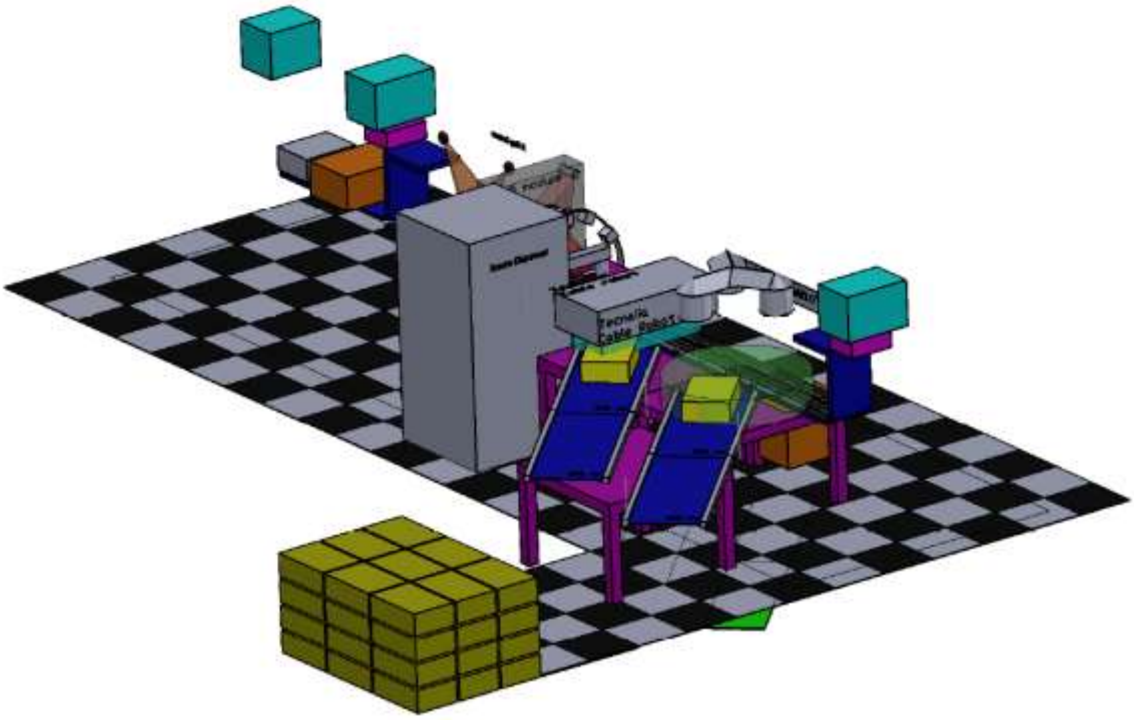




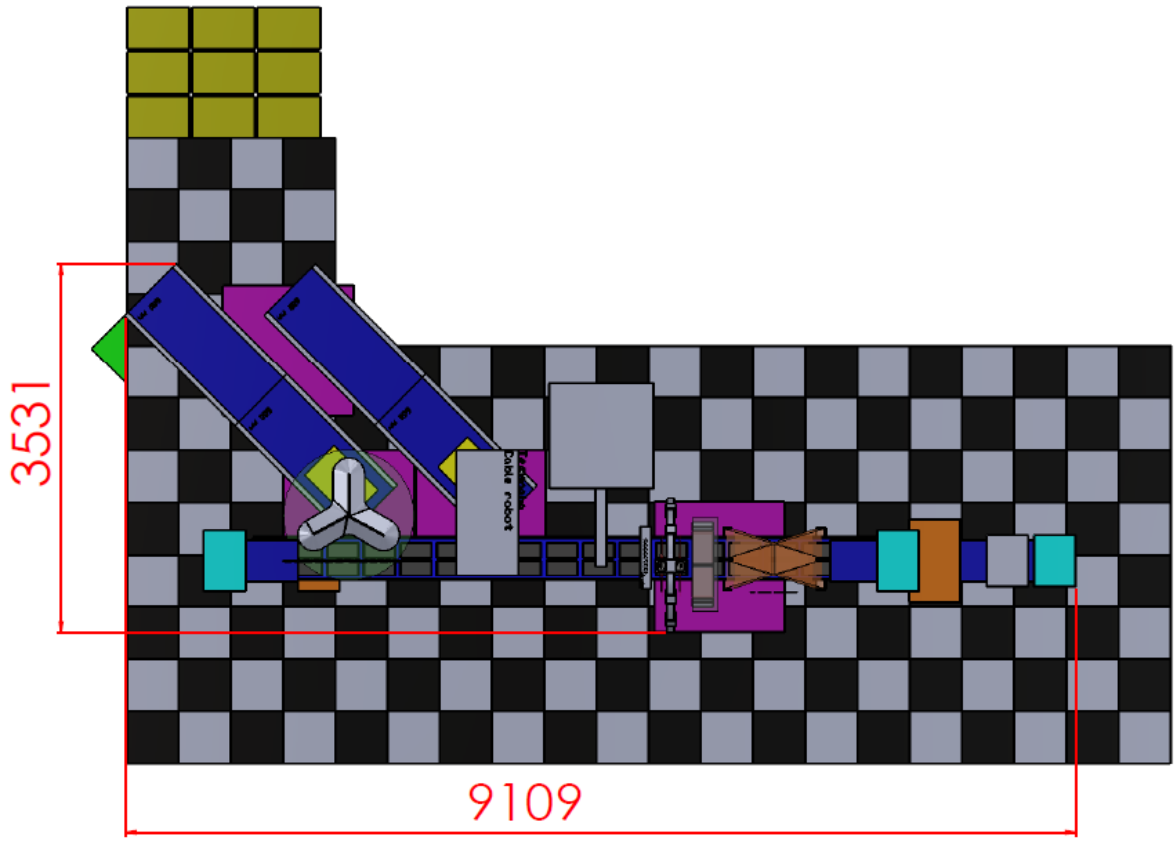
Fresh food line top view



Ready meals view 1



Ready meals view 2



Ready meals line top view

According to the sketches: The two robot modules and sensing module should fit on a packaging line with 6 meter of open trays available. Though the most uncertain part in this is the space needed by the X-ray sensor system. This is still an open question that has to be answered by work package 4, what are the exact dimensions of the sensor systems to be expected?

2.4 Capacity of the line

Within the line design we strive for a capacity of 30 packages / minute. The currently proposed packaging line is proposed to work with 420 mm wide under film. If the chamber length is 360 mm it is possible to produce 6 packs (180x120 mm) for tomatoes and 4 packs (210x180 mm) for ready meals. This will be a capacity of:

- Tomatoes: 40-45 packs/min.
- Ready meals: 25-30 packs/min.

The other modules should be capable to work with the same capacity, sensing and handling.

2.5 Major changeovers between ready meal and vine fruit applications

The major changeovers between ready meal and vine fruit applications consists of moving the sensing module from the conveyor belt to the packaging line. Furthermore both robots are to be considered bin picking when composing ready meals, instead of bin picking and pick n place operations in the case of vine fruit application.
During the Copenhagen meeting we decided to find ways to work without a conveyor belt in both ready meal and vine fruit applications. This has implications for the major changeovers and the positions at which sensing takes place in the line. From the hygienic design point of view, less conveyor belts are preferable over a separate conveyor belt.
Wheeling in and out modules, or mounting in and out modules are considered major changeovers as well. It could be that for cleaning in or out of place some modules have to be wheeled in or out. This has to further investigated what the consequences are.
Major changeovers are focused on the consequences of cleaning and show the flexibility of the line as a whole. Furthermore they show that flexibility is possible with a small line footprint maintained.

2.6 Minor changeovers within vine fruit and ready meal applications

Minor changeovers within vine fruit and ready meal applications are discussed here. In vine fruit applications the minor changeovers are changing between different types of vine tomato trusses, which means a change in gripper size and consequences for the vision detection for grasping these trusses. It also influences the packaging type, its dimensions, and the sensing modules. Settings will have to be changed. The same holds when vine fruit is changed to grapes, different grippers will have to be attached to the robot arm, a different package has to be selected. The line will have to be recalibrated after changing of grippers and package.

When the ready meal type is changed, which means that one of the three components is changed in the meal, this has consequences for the different modules. The meat component is for now defined as a chicken breast, no alternatives have been mentioned yet. Though, for the vegetable component carrots and peas are defined, these need different grippers and subsequent calibration and characteristics. The sensing module has to know what kind of meal is being produced, such that the right properties are gathered and that the correct information is shared between the modules that are being developed.

Minor changeovers have to be finished under 5 minutes and do preferably not include cleaning in place, as this takes much more time. Minor changeovers are focussed on the flexibility of the products that can be handled within the line.

2.7 User interfaces on the demonstrator applications

Each module will have its own user interface. This facilitates that the sensing, handling and packaging module can be developed on their own. These modules have to be able to show the generic PicknPack user interface as well. The information presented on the user interfaces is generated based on the software design framework developed by WP 2 software integration.

2.8 Minutes & conclusions Copenhagen workshops.

During the Copenhagen meeting (23-10-2013), a hardware integration workshop was held. The main goals of the workshops were to find agreement on the target line layout and the tasks to be performed by each party. 3 Mayor issues following out of these discussions were addressed:

- 1) Do we need a conveyor belt?
- 2) Do we want a Wheel in/out system?
- 3) Stop and go. Is that feasible?

1) Do we need a conveyor belt?

Pros

- Hygiene
- Efficiency
- Shows bin picking + packaging in one go
- Ready meals and Vine Fruit application will become more similar.
- Calibration becomes much easier.

Cons

- We need to investigate if we can do the sensing when product is in the package.

Conclusions:

We need to decide if we go for an conveyor or don't. We make the decision later when the deliverable is made: January 1st. In the meantime Leuven can run some tests, but they cannot decide on this alone, what are the criteria to make this decision? What is good enough?

It should be the ultimate goal to get rid of the conveyor belt, the conveyor belt is a backup plan.

2) Do we want a Wheel in/out system?

Pros
- Easy out of place cleaning
- Shows the flexibility
- Consortium can easy show the different applications

Cons
- Calibration issues. Every time we clean out of place, we need to recalibrate.
- It is large challenge which will delay the demonstrator.
- Cleaning is easier due with fixed system to the mechanical structure

Conclusions:
Clean out of place requires calibration. We do not want calibration every day. This implies we will require clean in place.

The Industrial Advisory Board should be asked for opinion on this.

Wp7 will built some scenarios and propose that to the consortium and the Industrial Advisory Board

3) Stop and go. Is that feasible?

Pro
- Easier for robotics? Not necessarily so.
- You need to know whats its moving: so this also implies that you need an accurate calibration.

Cons
- You cannot do something in the 7 seconds
- It reduces capacity
- Larger workspace required for the robot

Conclusions:
KU Leuven will investigate the implications.

DTI has suggested that a continuous flow is also possible with the packaging machine. They will take the lead in investigating this possibility, investigated in October and November 2013.

3 Software Integration

Both application designs pose constraints and requirements for the to be developed software system. The software should at least have the following features:

- Sharing:
  Derived relevant knowledge by a module should be accessible by other modules.
- Adaptation:
  Changeovers within and between applications cause the software to adapt.

3.1 Sharing

Besides handling physical products, each module also handles all kinds of information derived thereof, like locations or sizes. Therefore each module not only has material output, but also information output that is available for sharing with other modules that might take interest.
For example, in the fresh food application, the *'Delta Robot Source'* module could derive the number of tomatoes on a vine that is picked from the harvesting bin onto the conveyor belt. This information can then be requested by the sensing module in order to check if no tomato has been detached after the placing. The software framework should empower such behaviour.

3.2 Adaptation

Two types of changeovers can be distinguished in the Pick & Pack lines.

- Intra-changeovers (minor):
  A line can change in packaging food types. For example in the fresh food application, two types of vine tomatoes and grapes will be packaged. A changeover between tomato types or to grapes affects multiple settings, such a gripper type or packaging size. The software system should be able to adapt to these changes, setting up the correct communications and ontology.
- Inter-changeovers (large):
  A line can be transformed from the fresh food application to the ready meal application. This is a major changeover and has a big effect on the inputs and outputs of each module. The software system should be adaptive to cope with this.

4 Hygienic design and hardware integration guidelines

The following table lists the input from the draft deliverable 8.2 on which work package 7 will comment based on the current schematical drawings of the lines and the most detailed information of the integrated line design.

Table 1: Basic hygienic design check list

1.	**Identify product contact surfaces** The (machinery) surface which are exposed to the product (direct) and from which the product or other materials can drain, drip, diffuce or be drawn into (self returned) the product or product container (indirect).
R 1	*Within the company visits we did it was shown that there is a big difference between high care and low care zones in food processing companies. For example harvesting crates with tomatoes are not allowed in high care zones in ready meal companies. A good distinction in which zones the lines are used should be elaborated upon.*

3.	**Surfaces and geometry** • minimise joints (preference: welding) • avoid metal-to-metal contact • avoid sharp change overs or crevices • avoid thread ends • avoid sharps ends (radius> 6 mm) • draining
R 3	*The supports for the robots, sensing and packaging modules should be hygenic designed, they are not yet in the drawings as shown.*
4.	**Seals** • always elastomers • tightening on product side (15% compression) • limited tightening (fixed maximum compression) • enough space for elastomer expansion
R 4	*Sealings have not been defined yet. Though how the modules are linked to each other is important.*
5.	**Movable parts** • room for cleaning agents (humidification) • dynamic seal (rotating; moving) • leak detection; shaft cleaning
R 5	*Movable parts are mainly in the robots and the conveyor belts. Probably in the sensing module when adjustments have to be made.*

6.	**Materials**
	• non absorbent
	• non toxic
	• non corrosive
	• stainless steel
	• plastics and rubber (FDA-list)
	    o measure stability (water take up; thermal expansion; fillers; time; load)
	    o less alteration
	• glue- and lubricants (FDA/NSF list; H 1)

R 6	*It is not known yet what materials will be used, though these will be used as guideline.*

For the conceptual design of the layout of the packaging line the following aspects should be taken into consideration:

- Materials not permitted for use: wood, enamelware, uncoated aluminium, uncoated anodized aluminium.
- Inspection windows are made of shatter resistant material and easily removable.
- Separation between product contact and non-product contact areas prevents cross contamination during operations. Indirect product contact zone areas are designed as if they were product contact zone areas.
- Separation between product contact areas and non-product contact areas has to be determined by a risk analysis.

- Product contact surface areas: inaccessible surfaces shall allow access by disassembly using simple tools or a tool free design
- Where access is not possible, the entire assembled unit must be cleanable (i.e. Clening In Place).
- Product contact surfaces are constructed to prevent build-up of product residue during operations.
- Surfaces in non-product zones shall be accessible for cleaning and inspection.
- All surfaces near product contact zones are designed as if they were product contact zones.
- Equipment with hollow areas should be avoided, especially in wet operations.
- If hollow areas cannot be avoided, hollow tube construction, such as framework or blade spacers are fully sealed with continuous, hygienic welds to prevent interior contamination.
- No fastener penetrations into hollow tube construction.
- Round framework is used for horizontal framework pieces wherever possible.
- Equipment design has to provide a minimum 300 mm clearance from the floor to allow for cleaning and inspection.
- Equipment should be located a minimum of 760 mm from overhead structures and 920 mm from the nearest stationary object. (Check applicable safety regulations)
- Utility lines are a minimum of 300 mm off of the floor and cleanable.
- Installation for product contact areas and conveyor travel paths will maintain a minimum of 300 mm (400 mm is better) clearance from the floor.
- No bearings, drive, chain guards, control boxes or motors are located in or directly above product contact zones.
- Conduit and other utility supply lines are not routed above product contact areas.
- Fasteners are not used in or above the product zone.
- Control and junction boxes are fastened to the frame via welding or sealed or mounted away from the framework with a stand off and not mounted above product.
- No lap joints. This includes standing off flanged bearings. Bearings should be mounted on the outside of framework. They should be mounted as far from product and product contact surfaces as possible.
- Air used in contact with product or a food contact surface shall be filtered for oil, moisture and/or microbes. (Filtration requirements are based on a risk evaluation).
- Vacuum systems are considered as indirect product contact areas
- Motor fans do not blow air onto or in the direction of product contact surfaces.
- Cooling water, drain lines, drip pans (items with constant flowing water) must be piped and/or directed to a drain.
- Utility supply lines and piping are separated to prevent catch points and to allow for cleaning.
- Belts used as product contact surfaces should be non-absorbent, fully encapsulated (no exposed cloth backs or centers), cleanable.
- Belting is easily removable or the belt tension can be reduced so that the surfaces underneath belting can be easily accessed for cleaning.

4.1 Cleaning in or out of place?

Based on the visits at the ready meals factories we saw that there is a trend towards cleaning out of place. This gives the opportunity to keep the line, or at least the floor space in use during the production hours of the facility as much as possible. During minor changeovers during the day elements are exchanged, placed on cleaning trolleys, or complete modules are exchanged. During night time the floor space and non removable parts are cleaned in place.

Though the facilities we visited, the robotic modules could not be removed to be cleaned out of place. So only minor smaller parts and food contact parts could be removed or exchanged to be cleaned.

Cleaning trolleys as shown below produced by Marel are becoming common practice in the ready meal industry

5 Factsheet tomato production

This is the factsheet for vine tomato handling and packaging. It includes characteristics of the state of the art in current processing facilities, as well as the opportunities for PicknPack. These opportunities will be explored within the demonstrator that is the result of the integrated line, consisting of sensing, handling and packaging.

State of the art

Product specifications:

We will focus on two types of vine tomatoes: "middle truss" and "cocktail truss".

Min max weight:

Middle truss:

- Weight per truss:
  Min: 290 g
  1st quartile: 580 g
  Median: 632 g
  3rd quartile: 736 g
  Max: 976 g
- Number of tomatoes:
  Min: 3
  1st quartile: 5
  Median: 6
  3rd quartile: 6
  Max: 7

Cocktail truss:

- Weight per truss:
  Min: 156 g
  1st quartile: 326 g
  Median: 370 g
  3rd quartile: 404 g
  Max: 484 g
- Number of tomatoes:
  Min: 3
  1st quartile: 9
  Median: 10
  3rd quartile: 10
  Max: 12

Min max dimensions:

Middle truss:

- Average diameter of tomato: 47-72 mm
- Dimensions of the truss: 150-200 (length) x 100-140 (width) x 47-75 (height) mm*

Cocktail truss:

- Average diameter of tomato: 35-47 mm

- Dimensions of the truss: 140-230 (length) x 70-100 (width) x 35-50 (height) mm*

* This is an estimate based on the average number of tomatoes on the vine and the general diameters of the tomatoes.

Process specifications

Logistics / capacity:

Number of products / picks / minute:

Many different types of packages: 200, 300, 400, 500 en 1000 gr and different packages with a fixed number of tomatoes.

We currently don't have accurate numbers for the number of persons on a line, the number of picks and the number of packages per minute. A rough estimate would be 30 picks per second per person.

Hygienic constraints in current production locations:

Hairnet

Overall

Washing of hands

Input and output of the lines:

Input: harvest crate

- 78 harvest crates per pallet. These are automatically depalletized
- Middle truss: 16 vine tomatoes per harvest crate.
  2 layers of 4x2 trusses
- Cocktail truss:
  3 layers of trusses, total of 10 kg per crate

Output:

- 8, 10, 12 packages per box
- 56, 72 or 80 boxes per pallet

Changeover specifications (one product to another product)

There are many change overs (not specified how many), usually within the same product and package range. In that case, a change over takes about 4 minutes.

Limiting factors

What are limiting factors in current production / labour bottlenecks

The people cannot work faster without deteriorating the quality of the end product.

Where is the major human labour involved?

Unpacking the harvest crates

Quality check of the tomato trusses and potential removal of (part of) the truss

Cutting trusses in smaller pieces for the automatic combiner

Picking trusses from the conveyer belt and placing them in the package

Taking the sealed packages from the conveyer belt and placing them in carton boxes

What are limiting factors for quality control / sensing bottlenecks

Humans become "blind" after some time of working.

Automatic process for detecting cracks and cuts in the tomatoes.

Is a variable belt speed possible (dynamic change in capacity)

yes

Opportunities for PicknPack

Increase in quality measurements and tracing

More stable and objective quality assessment

Single tomatoes are already automatically sorted on their color (redness). This would be nice to also have for vine tomatoes

Automatic process for detecting cracks and cuts in the tomatoes.

Links between sensing and track and trace information

Increase in flexibility

Flexibility aspects

Modules can be replaced, or parts within modules can be exchanged to handle different vine fruits

Dynamically changing the belt speed in steps gives opportunities to increase capacity when minimal quality defects are measured, as well as to decrease capacity due to increased quality standards and delicate handling requirements.

Increase in adaptive behaviour

Handling

Bin picking

Adaptive packaging aspects

Increase in speed/efficiency

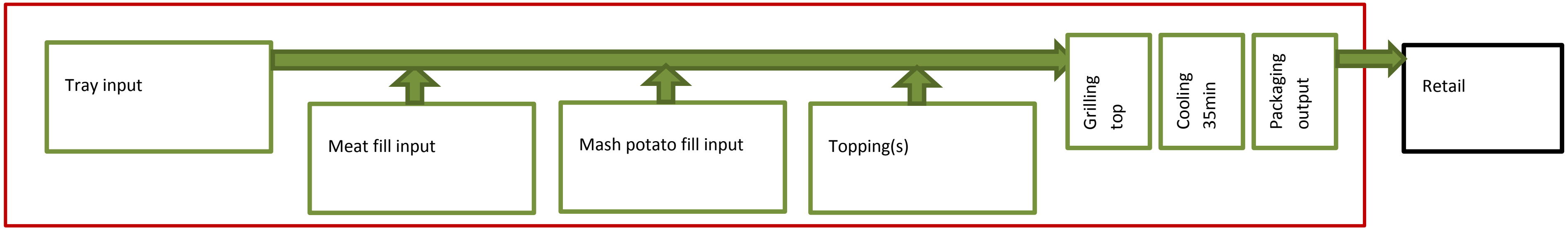
With increasing computation capacity and robotic-handling capacity, the PnP technologies will be able to be more efficient in years to come. Humans work at their limits.

Human quality assessment and handling capabilities deteriorate after some time of non-stop working. Robot and machine will continue on the same quality level.

PicknPack

6 Factsheet state of the art production of ready meals in England Annexes

Sheme of Pie production: Cottage, Shepherds and Cumberland; C&G Carlisle



Production line

Highly automated
People per line: 6
Products/line/week: 120.000 – 280.000
Production:
8h/day in summer – 20h/day in winter
Shifts per day: 3; 2 for production; 1 for cleaning
Changeover time: 20%
Uptime: 70%
Bottle neck: chilling/ cooling
Production filled out manually in excel

Capacity

Pie type: Small,medium, Large (9)

Packaging

Many different sizes in company are seen

Quality Control

Incoming goods only sample checks

Opportunities for PicknPack

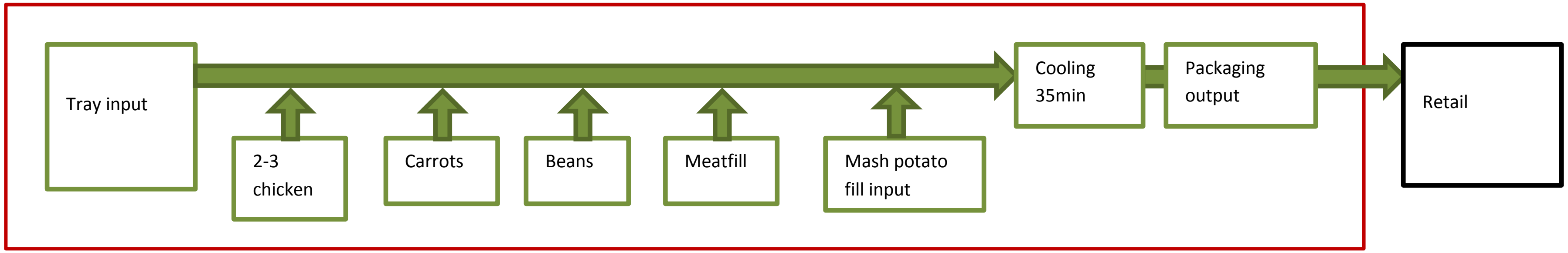
<u>Increase in quality measurements and tracing</u>

<u>Increase in flexibility</u>

<u>Increase in adaptive behaviour</u>

Scheme of 3-component meal production; C&G Carlisle

steak, liver or cottage meat with mashed potatoes and vegetables



Production line
Wish for automation
People per line: 16
Products/line/week: 120.000 – 280.000
Production: 8h/day in summer – 20h/day in winter
Shifts per day: 3; 2 for production; 1 for cleaning
Changeover time: 20%
Uptime: 70%
Bottle neck: labour (nr of people at the line)
Production filled out manually in excel

Capacity
Meals for 5-6 p

Packaging
Many different sizes in company are seen

Quality Control
Incoming goods only sample checks

Opportunities for PicknPack
Increase in quality measurements and tracing

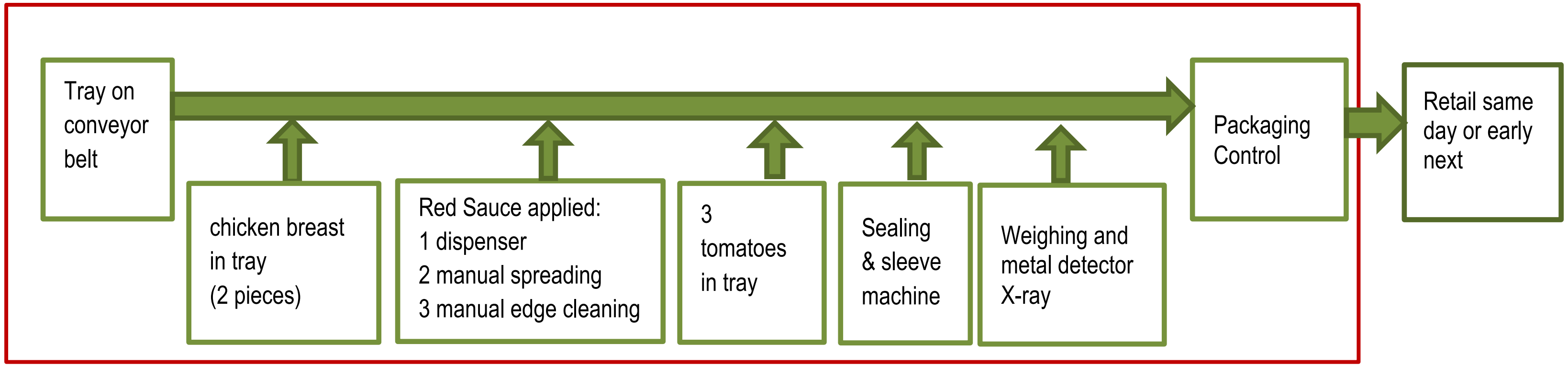
Increase in flexibility

Increase in adaptive behaviour

Wish for robotics
Filling different components
Package into boxes end of line
Small ishida fillers
Easy to apply, to change over easy to clean

Focus
Robots should be small and easy to apply and easy cleanable
Sensing can also be done upstream
Tell us what sensors can do and we will come with suitable applications. (end of Sep)
Things that come from the field are difficult to check (insects)

Scheme of ready meal line: chicken breast with red sauce, tomatoes and spices; Bakkavor



Production line

Automation/innovation needed
ready meals/minute: 30-45
Total company ready meals /year: 230M
Shifts per week: 2-3-2 (days on-off-on)
Labour: all handlings manually except sealing;
Employees:10 (line)+ 4 (packaging)

Failures: if occur, all have to wait till problem is solved
if packaging machine fails, sleeves are put manual
Bottle necks: quality checks now only when meal is ready for retail
labour on slow operations 2 (or more) employees do work
no replacements of machinery is possible

Capacity

The number of meals produced depends on demand.

Packaging

Sealing Machine per 4
Manually put sleeve around tray

Quality of products in the line

If applied:
Vegetables are visually controlled when weighed and put in the tray
rice is manually controlled on solids before cooking

Quality Control

Sensors: metal detector and scale at the end of the line
Detector is calibrated every 30 minutes. All have to wait

No software/ vision control in the line

When meals are in crates and ready to go to retail the temperature is measured: whether allowed to pass or not

Opportunities for PicknPack

Increase in quality measurements and tracing
Implement systematically inspection:
Vision technique at critical points in the line
Quality control at critical points in the line
Sensing in the line to comply with standard

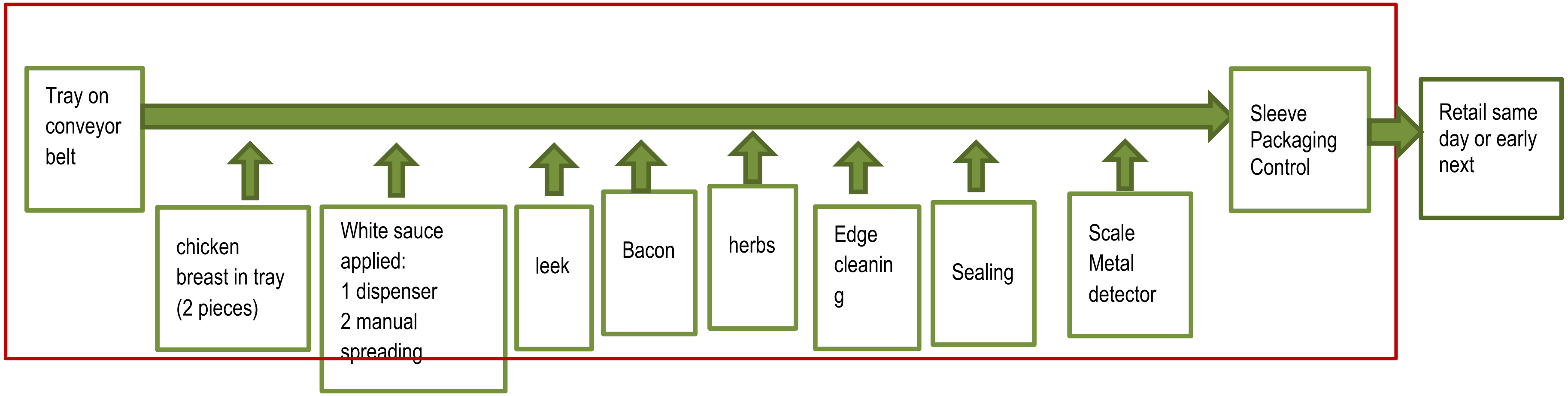
Increase in flexibility
Online printing could increase flexibility

Increase in adaptive behaviour

For both chicken meals with red or white sauce, the sauce needs to be spread manually after dispensing and edge of tray needs to be cleaned. Possibility to combine dispenser types to one?

PicknPack

Scheme of ready meal line : chicken breast with white sauce, leek and bacon; Bakkavor



Production line

Automation/innovation needed
ready meals/minute: 30-45
Total company ready meals /year: 230M
Shifts per week: 2-3-2 (days on-off-on)
Labour: all handlings manually except tray on belt and sealing;
Employees:10 (line)+ 2 (packaging)

Failures: if occur, all have to wait till problem is solved
Bottle necks: quality check when meal is ready for retail
labour on slow operations 2 (or more) employees do work
no replacements of machinery is possible
50 kg batches of components

Capacity

Number of meals produced depend on demand.
Varies with season

Packaging

Sealing Machine per 4
Automatically sleeve packing

Quality of products in the line

If applied:
Vegetables are visually controlled when weighed and put in the tray
rice is manually controlled on solids before cooking

Quality Control

Sensors: metal detector and scale at the end of some lines

No software/ vision control in the line

When meals are in crates and ready to go to retail the temperature is measured: whether allowed to pass or not

Opportunities for PicknPack

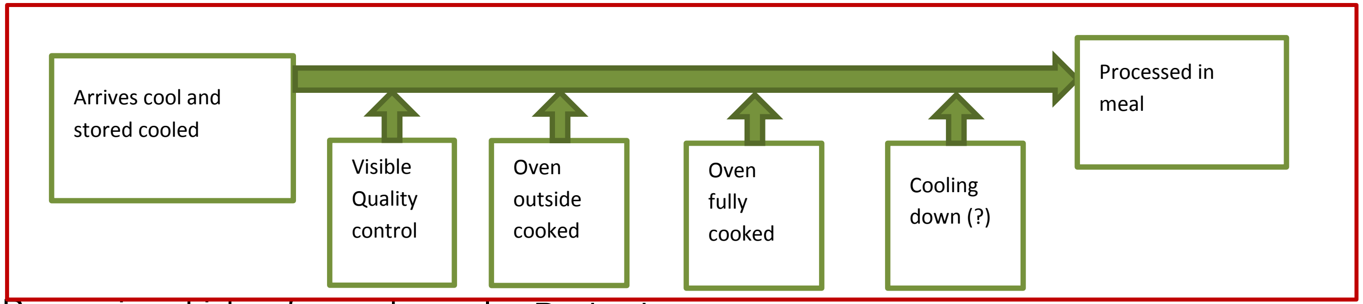
Increase in quality measurements and tracing
Implement systematically inspection:
Vision technique at critical points in the line
Quality control at critical points in the line
Sensing in the line to comply with standard

Increase in flexibility
Online printing could increase flexibility

Increase in adaptive behaviour

For both chicken meals with red or white sauce, the sauce needs to be spread manually after dispensing and edge of tray needs to be cleaned. Possibility to combine dispenser types to one?

Scheme of processing chicken breast for ready meal



Processing chicken for ready meal

Automation/innovation needed
ready meals/minute: 30-45
Shifts per week: 2-3-2 (days on-off-on)

Labour: all handlings,
except for 'meal control' weight and foreign bodies at the end of the line

points of quality control:
the incoming chicken breast
after the meal is prepared and packed:
control on foreign bodies

Capacity

Processed per batch
3,5 – 4 ton/day (?)

Note about cooling down cooked chicken:
Vegetables/rice are cooled in three steps before applied in the meal.
Suppose, but not seen it for chicken.

Packaging

arrives in crates
transported in crates to different locations in factory

Quality

Between batches a hand cleaning will do
End of the day a deep cleaning

Tracking and tracing of meals (RFID tag, bar code, text))

Quality Control

Before processing:
Visible quality control: per 5 trays of one tray:
Temperature
Then: 30 breasts of the selected tray
Haemorrhage, colour, dehydration
Presence of foreign bodies
Fat content
In case of wings: wing damage
Weight control (min, avg, max)

Quality check on foreign bodies (in case of breast) when meal is prepared and ready to go to retail

The temperature of the meals should be lower than 7^{o}C at arrival to be transported

Opportunities for PicknPack

<u>Increase in quality measurements and tracing</u>
Use of vision techniques for quality measurements of the incoming chicken and at other important points between beginning and end of the line (sensing modules at incoming product).
Sensing in the line to comply with standard

<u>Increase in flexibility</u>

<u>Increase in adaptive behaviour</u>
If automation enters the line, employees need to be trained.