RISK MANAGEMENT

Risk management
Introduction

Risk is uncertain event that, if it occurs, has positive or negative effect on at least one project objective such as scope, time, cost or quality

- Positive risks are opportunities
- Negative risks are threats

Projects always contain risks. If you do not manage project risks, they will derail your projects!

- A risk can have one or several causes, and one or several impacts
- Art of project management is risk management. When done efficiently, risks can be reduced by over 80%

Risk management
Methodology

Risk identification

- Determine which risks might affect project; document their characteristics

Qualitative risk analysis

- Prioritize risks for further analysis or action

Quantitative risk analysis – only if worth it

- Numerically analyze effect of identified risks on overall project objectives

Risk response planning

- Develop options and actions to enhance opportunities and reduce threats

Risk monitoring and control

- Track identified risks, monitoring residual risks, identify new risks, execute risk response plans

Risk management
Methodology

Main tool for risk analysis is Risk Register

INITIAL RISK ASSESSMENT - THREATS									
ID	Risk	Category	Sub-category	Initial probability	Initial impact	Initial value	Strategy	Owner	Risk response
1	E.g. specifications unclear	Technical	Requirements	8	8	64	Mitigate		Schedule regular meetings with customer
2	E.g. € decline, impacting target product margin	External	Market	8	4	32	Avoid		Find suppliers in € zone
3	E.g. new requirements added without additional budget	Project management	Planning	4	4	16	Mitigate		Limit acceptance of new requirements
4						0			

Risk management
Methodology

Define rules for risk assessment

Categories	Sub-categories	Probability	Impact*	Threats response strategy	Opportunities response strategy
Technical	Requirements, technology, complexity, interfaces, performance, reliability, availability, quality	8 = very high	8 = very high	Avoid	Exploit
External	Sub-contractors, suppliers, regulatory, market, customer	4 = high	4 = high	Transfer	Enhance
Organizational	Project dependencies, ressources, funding, prioritization	2 = moderate	2 = moderate	Mitigate	Share
Project management	Estimating, planning, controlling, communication	1 = low	1 = low	Accept	Accept

* Definition of impact scale

	Low (1)	Moderate (2)	High (4)	Very high (8)
COST	< 10% increase	10-20% increase	20-40% increase	> 40% increase
TIME	< 5% increase	5-10% increase	10-20% increase	> 20% increase
SCOPE	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
QUALITY	Only very demanding applications affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

Risk management
Methodology

Risk response strategies for threats

- Avoid

  Eliminate threat by eliminating cause (e.g. remove work package), isolate project objectives from impact, relax objectives, clarify requirements, improve communication, acquire know-how

- Mitigate

  Reduce probability or impact of threat, making it smaller risk. Reinforce test plan, choose more reliable supplier, build prototype

- Transfer

  Make another party responsible for risk, e.g. by outsourcing the work, purchasing insurance

- Accept

  Active acceptance involve creation of contingency plans and contingency reserves to be implemented if risk occurs. Passive acceptance leaves actions to be determined as needed, if (after) the risk occurs

Risk management
Methodology

Risk response strategies for opportunities

- Exploit

  Exploit opportunity, e.g. add work or change project to make sure that opportunity occurs, use better resources, improve quality, add functionality, …

- Enhance

  Increase likelihood (probability) and / or positive impacts of risk event

- Share

  Allocate ownership of opportunity to third party (forming partnership, team, joint venture) that is best able to achieve the opportunity

- Accept

  Do not implement any action

Risk management
Methodology

Probability and impact matrix for threats

Risks with highest probability and impact levels must receive focus

		IMPACT			
		1	2	4	8
PROBABILITY	8	8	16	32	64
	4	4	8	16	32
	2	2	4	8	16
	1	1	2	4	8

These risks require priority actions and aggressive risk response strategies.
These risks require actions and a risk reponse strategy. Implement risk response if risks move to above category or if time allows.
These risks are not critical. They are documented for periodic review.

Risk management
Methodology

Example of Risk Register for case study, filled out with extended project team

INITIAL RISK ASSESSMENT - THREATS									
ID	Risk	Category	Sub-category	Initial probability	Initial impact	Initial value	Strategy	Owner	Risk response
12	Jitter and jam due to data quantity	Technical	Performance	4	8	32	Mitigate	R&D QC	Perform test on prototype ASAP
29	Precision of detection of vertical embossing	Technical	Performance	4	8	32	Mitigate	S&A	Perform customer trials (with broad range of samples)
34	Technology of industrialisation	Technical	Complexity	4	8	32	Mitigate	Indus CORES	Try asembly setup, and/or investigate alternative solutions
23	Ending up with a complex HMI	External	Customer	3	8	24	Mitigate	S&A	Involve S&A and field service techs from the start
32	Not reaching product introduction targets	Project management	Ressources	4	4	16	Mitigate	Mgmt	Filter requests for current product evolutions
2	Processing time	Technical	Availability	8	2	16	Mitigate	Indus CORES	Buy from well known seller
7	Inability to synchronize mechanical displacement of box with image acquisition	Technical	Requirements	4	4	16	Mitigate	S&A	Tests on PCR machine with camera
15	Insufficient processing power for framerate	Technical	Performance	2	8	16	Mitigate	R&D QC	Perform test on prototype ASAP
17	Accuracy and repetitivity on low contrast mark with noisy substrate	Technical	Performance	4	4	16	Mitigate	R&D QC	Perform test on prototype ASAP
25	Perturbation caused by dust	External	Reliability	2	8	16	Mitigate	Indus CORES	Today's solutions are acceptable; analyse and if necessary improve current solutions
1	€ decline, impacting of Fx on product and project cost	External	Market	2	4	8	Accept	Indus CORES	Find suppliers in € zone
3	Llife time of processing unit	Technical	Reliability	4	2	8	Accept	S&A	Mitigation solution exists
4	Artefacts due to rotation between cameras	Technical	Quality	2	4	8	Accept	R&D QC	

Risk management
Methodology

INITIAL RISK ASSESSMENT - THREATS									
ID	Risk	Category	Sub-category	Initial probability	Initial impact	Initial value	Strategy	Owner	Risk response
5	Dependence on single supplier	External	Suppliers	1	8	8	Accept	Indus CORES	
6	Desynchronization b/w camera and lights	Technical	Reliability	2	4	8	Accept	R&D QC	Resynchronisation on every top-frame
11	Fail to provide stable color measurement	Technical	Requirements	2	4	8	Accept	R&D QC	Backup: sample over more boxes
18	Precision of register measurment	Technical	Performance	2	4	8	Mitigate	S&A	
19	Detection of defect while register tolerance is large	Technical	Reliability	4	2	8	Accept	QC	Define a CDC
33	Availability of Senior Project Manager	Project management	Ressources	2	2	4	Accept	Mgmt	
8	Modification of reporting tool	External	Estimating	4	1	4	Accept	CUBE	CDC to be defined Impact on time and budget
9	Unreliable cooling fan into production plan (lifetime, downtime, ...)	Technical	Reliability	1	4	4	Mitigate	CUBE	Decision to use cooling
14	Non real-time OS	Technical	Reliability	1	4	4	Accept	R&D QC	Knowledge based onto actual systems
20	Reliability of electronic/LEDs	Technical	Reliability	1	4	4	Accept	CUBE	Electronic will be in producer specification
21	Unreliable white balancing/gain	Technical	Performance	2	2	4	Accept	S&A	
22	Impact on ressources	Technical	Availability	2	2	4	Mitigate	WFS	
31	Incomplete knowledge of customer requirements (process, needs, applicability, uses, ...)	External	Customer	2	2	4	Accept	Mgmt	
13	Bandwidth between state machine and IHM for image transfer	Technical	Performance	1	2	2	Mitigate	CUBE	Tests to be performed ASAP

Risk management
Methodology

Quantitative risk analysis: numerically analyze effect on overall project objectives of identified risks

Purpose:

- Determine which risk events warrant a response
- Determine overall project risk
- Determine cost and schedule reserves

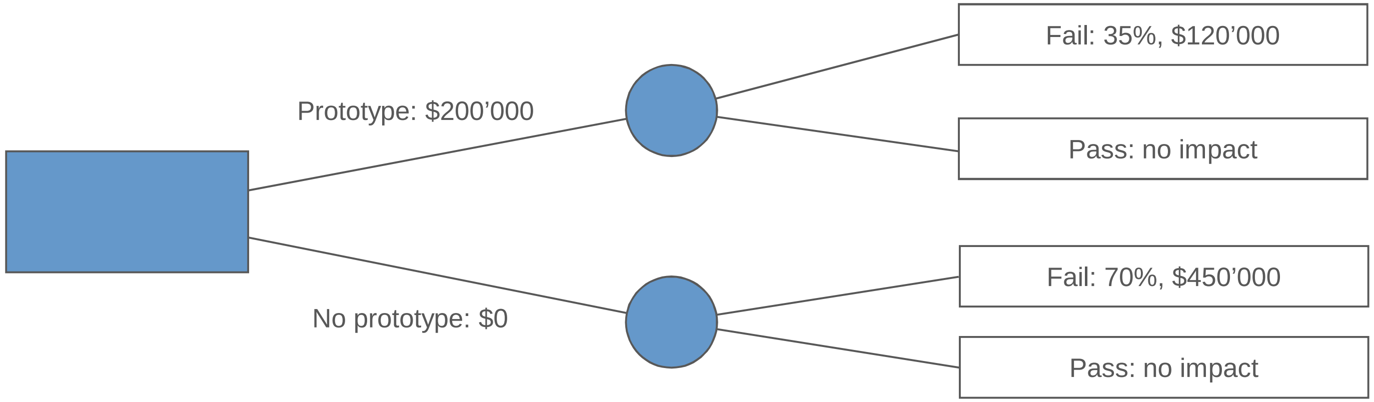
Expected Monetary Value (EMV) provides overall ranking of risks

EMV = Probability * Impact

Risk management
Methodology

EMV can be combined with decision trees

- Example: is it worth to build a prototype for our project?
- Assumptions:
  - Failure if no prototype is built: 70% probability, $450'000 impact
  - Cost of prototype is $200'000
  - Failure even if prototype is built: 35% probability, $120'000 impact



$EMV_{\text{Prototype}}$ = $200'000 + 0.35 * $120'000 = $242'000
$EMV_{\text{No prototype}}$ = 0.70 * $450'000 = $315'000

Conclusion: better to build a prototype!

Risk management
Methodology

Risk response planning: implement actions to reduce risk level and risk mitigation reserves

- **Residual risks**
  - Risks that remain after risk response planning (e.g. accepted risks)
  - Residual risks should be documented and monitored
- **Contingency reserves**
  - Determine amount of contingency time and cost reserves needed to cover **identified risks**. E.g. the project requires 2 months time and $120’000 to accomodate the known risks on the project
  - Contingency reserves are included in cost baseline
- **Management reserves**
  - Account for **unknowns**; items you could not identify in risk management
  - Management reserves are estimated top-down (e.g. 5% of project cost)

Risk management
Methodology

Risk management is a key activity in project management

- Risk management should be performed on every medium or large size project

- Risk Register template makes it easy to implement and track risk management

QUALITY MANAGEMENT

Quality management
Introduction

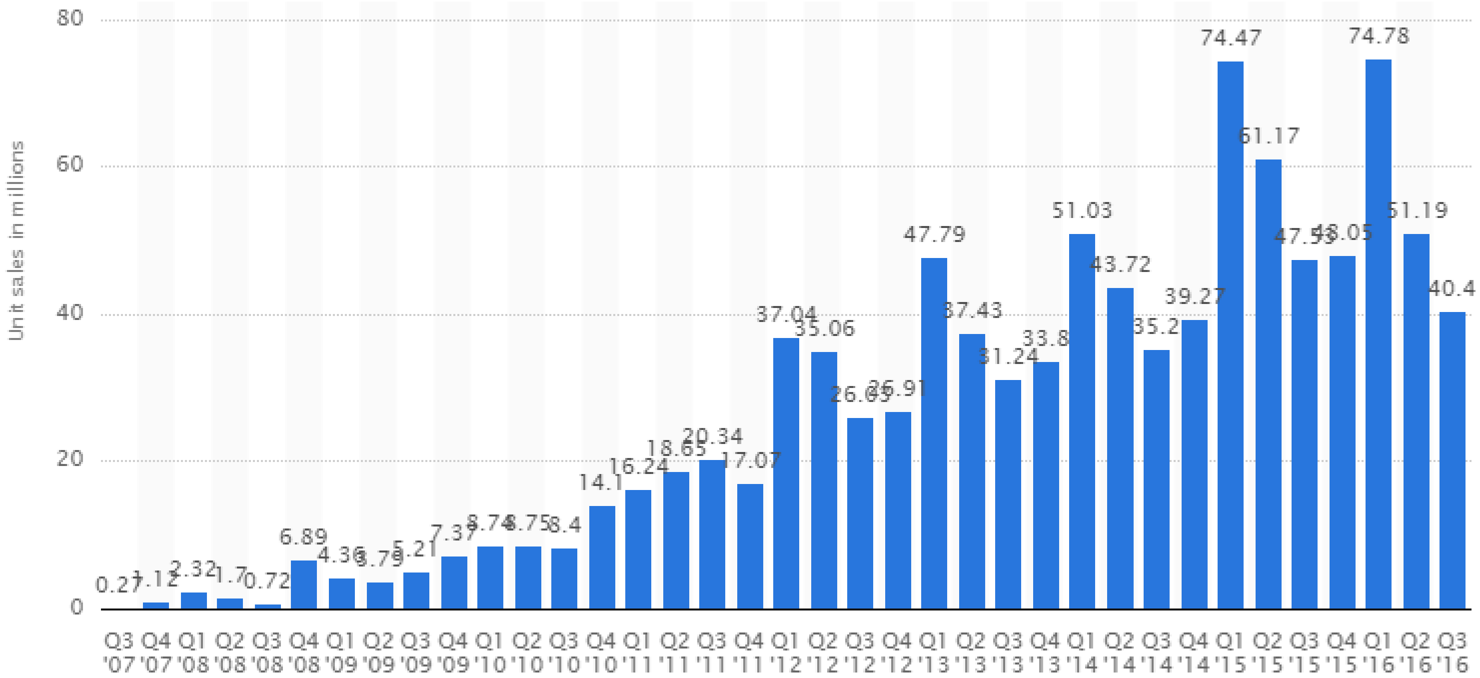
Products can suffer from

- Hardware-related product quality (now) and reliability (over time period) issues, often due to
  - Component failures (choose reliable suppliers during product design!)
  - Poor design choices during product design (e.g. antennagate with iPhone 4 in 2010, impact of thermal and EMC management, …)
- Software-related quality (e.g. bugs, poor usability or learnability) and reliability issues (e.g. memory leaks)
- Other issues (e.g. poor packaging or user documentation)

Quality management
Introduction

Case study showing impact of hardware quality issues

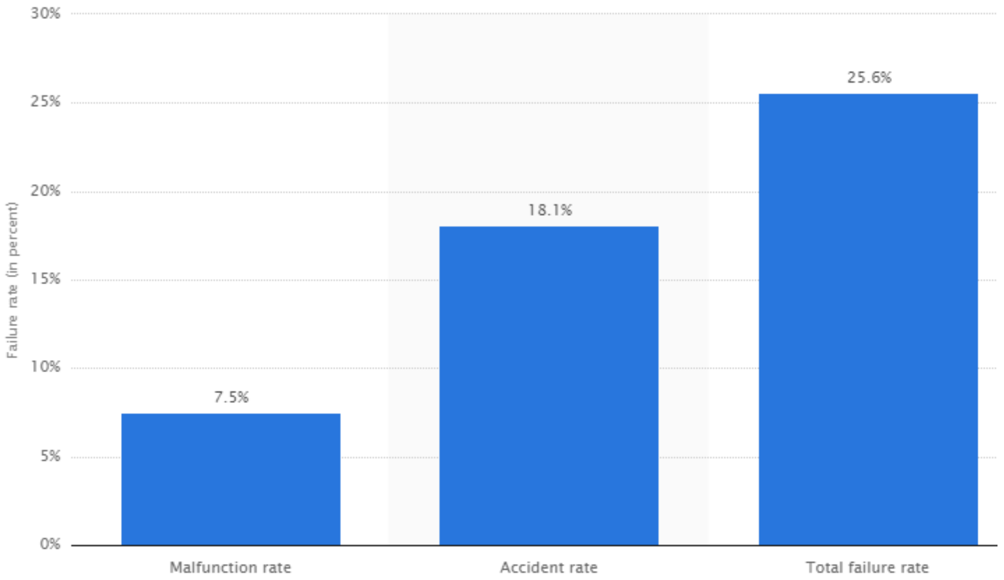
iPhone sales have risen strongly from 1.4 million units in 2007 to **230 million units in 2015**. In July 2016, Apple sold its billionth iPhone



Quality management
Introduction

Statistic below shows failure rates for iPhones, 2 years after item purchase in the United States in 2010, by type of failure.

Product malfunction rate is 7.5%



Quality management
Introduction

Assuming 1-year warranty, 230 million units sold in 2015 and 7.5% malfunction rate split equally over 2 years, it means that Apple replaced ~ 8.6 million of these iPhones in 2016.

A 16GB iPhone 6S Plus costs about $236 to build: $231 for Bill of materials (BOM) and $5 for manufacturing costs. Assume that defective devices are replaced for $200 apiece.

Cost of non-quality for iPhone is ~ $1.7bn annually, directly impacting company's margin of $50 bn.

A $100m project that would cut non-quality by 30% would be paid off in 2 months!

Quality management
Introduction

Managing quality in projects is more than ensuring good product quality and reliability. It means that

- Project delivers results that are required and have been agreed on, e.g. reaching product performance, product quality and reliability levels, project budget and time-to-market
- Product or service can be used for purpose it was designed for
- Project is managed in adherence with the company's rules & standards

At project beginning

- Check if project could be affected by quality regulations (regulations, norms, standards)
- Define quality procedures, guidelines and methods which apply to project or refer to relevant documentation in company’s quality policy

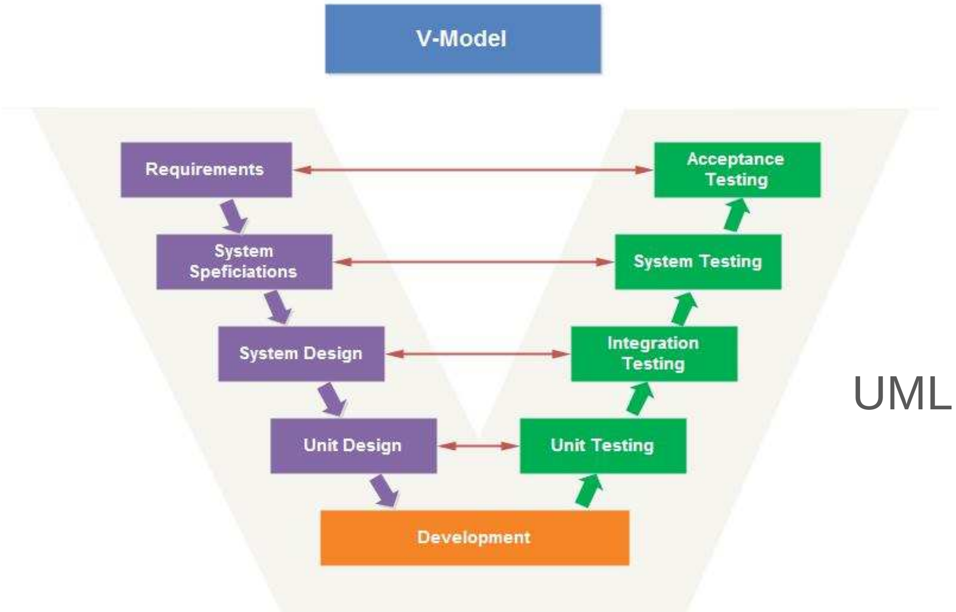
Quality management
Introduction

Agree on quality metrics for each project result, and later use same criteria for project acceptance. **Write test plan**, defining how product (prototype, pre-series and series) will be tested

- Product reliability: availability (MTTF, MTBF), failure rate
- Environmental sustainability
- Accuracy or operations carried out and repeatability
- Static and dynamic performance
- Rust adhesion and weather resistance
- Mechanical strength
- Resistance to vibrations, temperature, …

Quality management
V-model

V-Model, e.g. used to ensure software or firmware quality, **demonstrates relationships between each phase of development lifecycle and corresponding tests to be performed** to ensure product quality



UML modeling

Quality management
FMEA

Failure Mode Effects Analysis (FMEA) – “Analyse des modes de défaillance, de leurs effets et de leur criticité (AMDEC)” in French, is preventive quality method used to prevent potential flaws, **increasing product reliability level**

- Methodology used during development phase of new products
- Identifies flaws and potential causes of failures during design phase, allowing preventive corrective actions to be taken early and avoiding need for costly late design changes
- Anticipate issues early allows to design out failures and design in reliable, safe and customer-pleasing features, increasing customer satisfaction

Quality management
FMEA

Methodology to conduct FMEA

- Determine participants
  - Diverse team of people with experience should be involved in order to catch potential failure modes
- Format similar to brainstorming session
  - Identify components, systems, processes and functions that could fail to meet the required level of quality or reliability
  - Do not only describe effects of failure, but also causes
  - For each potential failure mode, determine **SEVERITY**, **OCCURRENCE** and **DETECTION** levels, then prioritize failure modes
  - Determine action plan

Quality management
FMEA

Use of FMEA template

Project name: FMEA for Car Tire
Project number:
Project manager:
Date:

Failure Mode and Effect Analysis

IDENTIFIED FAILURE MODES											IDENTIFIED ACTIONS						
													Forecasted effect				
ID	Item / Function	Potential failure mode	Potential effects of failure	SEVERITY	Potential cause / Mechanism of failure	OCCURRENCE	Current controls prevention	Current controls detection	DETECTION	RPN	Recommended actions	Owner & completion date	SEVERITY	OCCURRENCE	DETECTION	RPN	Actions taken & effective date
2	Traction of car	Wrong profile for season	Potential trafic accident due to poor grip	10	Driving on snow without proper equipment	4	Chek out for weather forecast before journey. Snow chains available.	External temperature	4	160	Change of tires at the change of the season, vehicle equiped with all year round tires, carry snow chains	Car owner 15.11.2012	3	2	4	24	Car equiped with all year round tire and snow chains permanantely carried in the trunk
			Can lead to puncture		Bulge or bubble						Carry spare tire and						Tire inspection after every severe impac

Identify failures

Identify actions

Quality management
FMEA

Failure modes identification

IDENTIFIED FAILURE MODES											
ID	Item / Function	Potential failure mode	Potential effects of failure	SEVERITY	Potential cause / Mechanism of failure	OCCURRENCE	Current controls prevention	Current controls detection	DETECTION	RPN	
2	Traction of car	Wrong profile for season	Potential trafic accident due to poor grip	10	Driving on snow without proper equipment	4	Chek out for weather forecast before journey. Snow chains available.	External temperature	4	160	Ch char vehic ye
4	Support weight of car	Damaged tire	Can lead to puncture and potential trafic	10	Buldge or bubble on the sidewall of a	2	Tire checks before journey	None	7	140	C apr

Quality management
FMEA

Definition of criteria for FMEA analysis

	Severity	Occurence	Detection
1	Minor failure, provoking only a short break (< 5 min) and no noticeable degradation	Almost never	Premonitory indication of the failure that the operator can avoid through a preventive action or automatic alarm
2		Once every two years	
3	Average failure requiring a minor repair and provoking a production stop < 15 min	Once a year	Premonitory indication of the failure, but there is a risk that the operator will not detect it
4	Average failure requiring a minor repair and a production stop < 30 min	Once every six months	
5	Cricital failure requiring an exchange of defective components and a production stop of < 1 hour	Once every three months	The premonitory indication of the failure is not easily detectable
6	Cricital failure requiring an exchange of defective components and a production stop of < 4 hours	Once a month	
7	Very cricital failure requiring an exchange of defective components and a production stop of < 8 hours	Once a week	There is no premonitory indication of the failure, apart the final inspection of the product
8	Very cricital failure requiring an exchange of defective components and a production stop of < 24 hours	Once a day	
9	Catastrophic failure requiring an intervention and a production stop of < 72 hours	Once every eight hours	There is no premonitory indication of the failure before the product is utilized by the customer
10	Catastrophic failure requiring an intervention and a production stop of >72 hours	Once every four hours	

Quality management
FMEA

Setting priorities

Risk Priority Number (RPN)

RPN = severity x occurrence x detection

Adjust the FMEA to list failures in descending RPN order

Apply Pareto rule: 80 percent of issues are caused by 20 percent of potential problems. Teams to focus attention on failures with top 20 percent of highest RPN scores.

Quality management
FMEA

Identify corrective actions

- Generate appropriate corrective actions for reducing the occurrence of failure modes at least for improving their detection

IDENTIFIED ACTIONS						
		Forecasted effect				
Recommended actions	Owner & completion date	SEVERITY	OCCURRENCE	DETECTION	RPN	Actions taken & effective date
Change of tires at the change of the season, vehicle equiped with all year round tires, carry snow chains	Car owner 15.11.2012	3	2	4	24	Car equiped with all year round tire and snow chains permanantely carried in the trunk
Carry spare tire and	Car ow					Tire inspection after every severe impact.

Quality management
FMEA

Example with case study

IDENTIFIED FAILURE MODES										
ID	Item / Function	Potential failure mode	Potential effects of failure	SEVERITY	Potential cause / Mechanism of failure	OCCURRENCE	Current controls prevention	Current controls detection	DETECTION	RPN
25	Assurer intégration machine	Vibrations	Defocus	6	Verrouillage défectueux	1	Audit de qualité	Cible de validation	2	12
28	Refroidir luminaires et caméra	Panne chiller	Échauffement des luminaires	9	Thermostat défaillant, pompe bloquée, …	2	Repect des prescriptions, entretien	Détection hardware de la T des luminaires, et arrêt	2	36
29	Refroidir luminaires et caméra	Défaut T régulation chiller	Échauffement des luminaires (si T >), condensation (T <), mesure couleur imprécise	8	Thermostat défaillant, mauvais réglage, …	1	Repect des prescriptions, entretien	Protection du chiller (+/- 5°) Protection software iQ (+/- x°)	2	16
30	Refroidir luminaires et caméra	Température de l'air trop élevée	Échauffement des luminaires (si T >), condensation (T <), mesure couleur imprécise	8	Température de l'environnement trop élevée	1	Repect des prescriptions	Protection du chiller (+/- 5°) Protection software iQ (+/- x°)	2	16
31	Refroidir luminaires et caméra	Fuite liquide de refroidissement : algues / corrosion	Échauffement des luminaires (si T >), mesure couleur imprécise	6	Qualité de l'eau, entretien non respecté, difficulté de mesure	1	Repect des prescriptions, entretien	Audit de qualité	2	12
32	Refroidir luminaires et caméra	Fuite liquide de refroidissement : connecteur défectueux	Échauffement des luminaires (si T >), mesure couleur imprécise, destruction électronique	9	Vieillissement tube plastique, joint mal serti	1	Respect des conditions de montage	Visuel	4	36
33	Refroidir luminaires et caméra	Panne capteur Température (carte électronique)	Échauffement des luminaires (si T >), mesure couleur imprécise	9	Vieillissement, court-circuit	1	Aucun	Contrôle croisé software (la T ne sera pas dans la bonne plage)	2	18
34	Refroidir luminaires et caméra	Panne capteur Température (transmission)	Échauffement des luminaires (si T >), condensation (T <), mesure couleur imprécise	9	Court-circuit, câblage défectueux, driver, …	1	Aucun	"Watchdog" hardware	1	9

PROJECT ECONOMICS

Project economics

New products are **launched to generate net profit margin** for company. Project financial viability must be demonstrated at project launch

- During project development company will only incur cost (=cash outflows). After product launch company will have residual project cost, and revenues will be generated (=cash inflows). After project closing company will incur only revenues

- When considering if investment shall be made in a project, company must consider the cost to borrow money, so-called weighted average cost of capital (WACC)

Project economics
Methodology

Step 1: estimate overall **project cost over time**

PROJECT COSTS

	Until Gate 7 (costs until G3 included)			Costs until Gate 7 splitted per year									
Activity	**Hours**	**kCHF**	**%**	**2016**		**2017**		**2018**		**2019**		**2020**	
R&D Mechanical		500	28%										
R&D Electrical		300	17%										
R&D Validation		100	6%										
R&D Pre-serial and Updates		30	2%										
R&D Project Management and Support		100	6%										
Subtotal R&D costs	**0**	**1030**	**57%**		**5%**		**40%**		**40%**		**15%**		**0%**
SPL Industrialisation		150	8%										
SPL Project Management and Support		50	3%										
Subtotal SPL costs	**0**	**200**	**11%**		**5%**		**20%**		**60%**		**15%**		**0%**
M/S Open House costs		50	3%										
M/S Tools, pictures, videos, brochures, advert.		50	3%										
M/S Boxes for open house, tests and demos		20	1%										
M/S Project Management and Support		30	2%										
Subtotal Marketing and Sales costs	**0**	**150**	**8%**		**5%**		**5%**		**50%**		**50%**		**0%**
Services Field Interventions		100	6%										
Services Technician Training		20	1%										
Services Warranty		80	4%										
Services Project Management and Support		20	1%										
Subtotal Services costs	**0**	**220**	**12%**		**5%**		**0%**		**50%**		**50%**		**0%**
Risk reserve	-	200	11%		**10%**		**20%**		**20%**		**30%**		**20%**
Total costs Base case	**0**	**1800**	**100%**	**100**	**6%**	**499.5**	**28%**	**757**	**42%**	**429.5**	**24%**	**40**	**2%**
Total costs Worst case	-	1980	110%	110	6%	549	28%	833	42%	472	24%	44	2%
Total costs Best case	-	1620	90%	90	6%	450	28%	681	42%	387	24%	36	2%

Project economics
Methodology

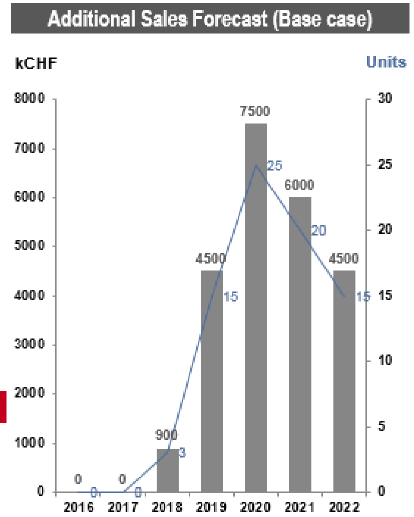
Step 2: estimate **margin obtained from selling the product**

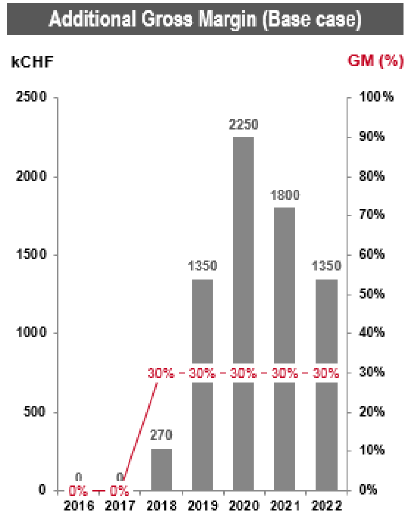
TARGET PRODUCTION COSTS

	kCHF	%
End User Price (EUP)	**300**	**100%**
Gross Margin	90	30%
Training / Instruction	5	2%
Others	5	2%
Cost of Sales (COS)	**200**	**67%**
Engineering / Specialty	25	8%
Transports / Insurance	10	3%
Installation	10	3%
Cost of Goods Sold (COGS)	**155**	**52%**
Packaging	5	2%
Machine Production Costs	150	50%
		0%

Project economics
Methodology

Step 3: estimate **sales forecast over time**





SALES FORECAST

Worst Case represents	80%	of Base Case GM Forecast
Best Case represents	120%	of Base Case GM Forecast

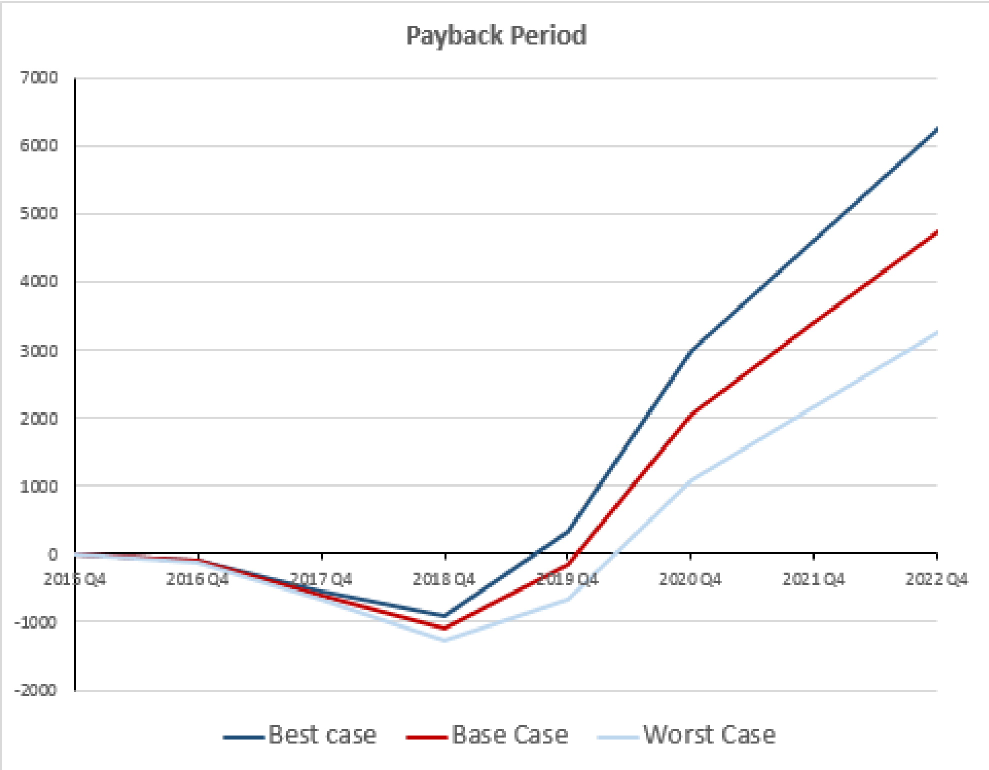
Additional Sales Forecast (Base Case)	EUP	GM/ Unit	Current Sales/Y	ADDITIONAL (DELTA Δ) SALES / YEAR 2016	2017	2018	2019	2020	2021	2022
New product (no cannibalization)	300	90	0			3	15	25	20	15
Total Additional Sales Forecast (Units)	-	-		**0**	**0**	**3**	**15**	**25**	**20**	**15**
Total Additional TO	-	-		**0**	**0**	**900**	**4500**	**7500**	**6000**	**4500**
Total Additional GM	-	-		**0**	**0**	**270**	**1350**	**2250**	**1800**	**1350**
GM (%)	-	-		**0%**	**0%**	**30%**	**30%**	**30%**	**30%**	**30%**
GM Worst Case	-	-		0	0	216	1080	1800	1440	1080
GM Best Case	-	-		0	0	324	1620	2700	2160	1620

Project economics
Methodology

Calculate project metrics: Net Present Value and Payback time

PROJECT PROFITABILITY

Gate 2		01.09.2016
Gate 3 estimated		01.12.2016
Gate 6 (start serial production)		01.09.2018
First Ex-Works machine		01.11.2018
Gate 7 (end project)		01.06.2019
WACC		10.00%
Payback date (base case)		**27.01.2020**
Project costs (base case)	kCHF	1800
Additional annual TO (base case)	kCHF	7500
Additional annual GM (base case)	kCHF	2250
Net Present Value (NPV) 5 years from Gate 3		
Worst	kCHF	1'098
Base	kCHF	1'893
Best	kCHF	2'689
Payback in years since Gate 3		
Worst		3.5
Base		3.2
Best		2.8



Project economics

Net Present Value (NPV) is used in capital budgeting to analyze the profitability of projects. It represents difference between present value of cash inflows and the present value of cash outflows. A positive NPV indicates that projected earnings generated by project exceeds anticipated costs. Investment with positive NPV is profitable, with negative NPV will result in net loss

Year	Expenses	Revenues	Annual cash flow	Discounted cash flow (NPV) with 10% WACC	Cumulative NPV
2017	2’000	0	-2’000	-2’000	-2’000
2018	250	100	-150	-136	-2’136
2019	100	500	400	331	-1’806
2020	100	1000	900	676	-1’130
2021	100	1500	1400	956	-173
2022	100	2000	1900	1180	**1’006**
TOTAL	**2’650**	**5’100**	**2’450**	**1006**	

Project economics

Other indicators to determine if project will yield positive financial benefits

- **Internal Return Rate (IRR) in %** is discount rate that makes project have a zero NPV. It computes interest rate at which future costs equal future revenues. The higher the IRR the better!
- **Return on Investment (ROI) in %** measures financial gains of project in relation to its cost. ROI = ((project's financial gain – project cost) / project cost) x 100
- **Payback period in years** refers to period of time required to recoup the investment in project, to reach the break-even point. E.g. a $1000 investment made at start of year 1 which returned $500 at end of year 1 and year 2, respectively, would have a two-year payback period (neglecting WACC)

Project economics

Once a financial model is available, it can be useful to perform a sensitivity analysis to identify major drivers behind cumulated profit and to drive decisions during project, e.g.

- Trade development cost for time
- Increase development cost to further reduce product cost

REDUCING WASTE IN PRODUCT DEVELOPMENT

Waste in product development

Lean principles applied in variety of manufacturing processes, but **applications in product development are slower to come**

Estimated that **20-40% of product development effort is pure waste**, and that **60-80% of tasks are idle** at any given time

Lean principles **offer opportunities to improve product development value stream**

This chapter focusses on **waste identification** in product development processes

Waste in product development
Strategic waste

- **Overproduction**
  - Developing products that are not currently needed / not needed at all
  - Having too many products or options
  - Having too many development projects (lack of focus)
  - Overlap of strategic and non-strategic projects competing for limited resources
- **Selecting wrong projects**, not focussing on projects with highest ROI
- **Projects with poor risk identification and management** during development
- **Technologies acquired but later not used** (e.g. Quadline, Braille reading)
- **Poor make-vs-buy decisions**
- Poor understanding of **long-term customer needs**

Waste in product development
Organizational waste

- **Poor organization structure**
  - Poor development process
  - Inefficient gates validation process
  - Project objectives not clear
  - Roles and responsibilities not clear / not understood
  - Lack of cooperation between departments or teams (silos)
  - Insufficient responsibility of project team
  - Poor tracking of project planning and cost, and product cost
  - Poor training of team members
  - Inappropriate selection of project team members
  - Team spread over different locations
  - Not taking advantage of lessons learned
  - Projects started without sufficient resources

Waste in product development
Organizational waste

- **Waste of human potential**
  - Strenghts or skills of team members not used properly
  - Underutilizing people's knowledge and creativity
  - Lack of interdisciplinary coverage among team members
  - Lack of continuity during projects
  - Too much administration

- **Inappropriate processes and tools**
  - Inadequate product development processes
  - Poor understanding of development process
  - Changing processes
  - Use of inadequate tools and methodologies (e.g. using 2D instead of 3D)
  - Use of tools and methodologies that are not necessary
  - Insufficient IT resources

Waste in product development
Operational waste

- **Waiting.** No value is added while people wait for product to process or product waits for people or machines.

  - People waiting for data, answers, specifications, requirements, test results, approvals, validations, decisions, project launch, design reviews, hand offs, task dependencies, prototypes
  - Information waiting for people, created too early
  - Projects / tasks waiting for resource availability
  - Delivery postponed (components, information, test results)
  - Unbalanced workflow within the team

Waste in product development
Operational waste

- **Transport**
  - Team members traveling between sites
  - Inefficient communication
  - Misunderstandings and non-conformities
  - Lack of process standardization
  - Lack of standardized components utilization
  - Lack of priorization
  - Lack of standardized and compatible data formats
  - Poor information systems requiring manual transfer and conversion issues
  - Poor interface controls and database transfers between sites / departments
  - Transfer of products / processes from one department to another
  - Multitasking, tasks being started and paused

Waste in product development
Operational waste

- **Inventory** is collection of unprocessed documents, data objects, and transactions queued-up between people and processes

  - Unnecessary details and information (e.g. on drawings)
  - Incomplete content
  - Poor management of configuration
  - Poor codification of components
  - Too much data stored, making it hard to find relevant information on server
  - Unnecessary test equipment or prototypes
  - Queues on critical path
  - Projects waiting, people waiting, resource overcapacity

Waste in product development
Operational waste

- **Movement.** Excess movement by people or equipment consumes time and resources without producing value

  - Information pushed to wrong people
  - Unnecessary manual interventions because of poor system connectivity
  - Too many data interfaces
  - Delocalized development sites
  - Lack of direct access to information or resources
  - Software efficiency: number of mouse clicks, of routines, of transactions
  - Searching for drawings and other information on remote servers

Waste in product development
Operational waste

- **Excess processing.** Doing more than what is necessary to generate satisfactory value as defined by the customer
    - Unnecessary tasks, development activities, sequencial treatment of tasks
    - Work not done in proper sequence because of poor integration
    - Change requests due to changing priorities, product or process requirements
    - Over-specifications, changing product requirements
    - Over-designed or over-engineered product
    - Too many design iterations
    - Work with wrong or incomplete information
    - Information passed on too early or too late
    - Data acquired but not used
    - Tolerances too tight
    - Too many details or unnecessary information
    - Redundant tasks or development (insufficient design reuse)
    - Poor reuse of knowledge

Waste in product development
Operational waste

- **Defects** are the result of executed processes that did not produce value
  - Improper information on drawings, missing views, undocumented software code
  - Rework of product
  - Incomplete information or errors in BOM and other R&D documents
  - Lack of understanding of product requirements
  - Errors during parts procurement, prototype assembly, installation
  - Product flaws resulting in missing specifications or customer expectations
  - Errors in configuration management
  - Errors in planification
  - Poor selection of suppliers
  - Use of immature or risky technologies
  - Use of inappropriate tools
  - Errors in communication and data
  - Errors in tests and reports

Waste in product development

8 lean product development questions

1. **Can we eliminate?** Remove unnecessary features
2. **Can we reduce?** E.g. use inflating device instead of spare tire
3. **Can we substitute?** E.g. tablets are substituting newspapers
4. **Can we separate?** Separate and combine work into smaller chuncks that are easier to outsource, manufacture, maintain
5. **Can we integrate?** Combine to create new solutions (e.g. waffle and ice cream)
6. **Can we re-use?** Avoid cost and risk of development, e.g. using platforming
7. **Can we standardize?** One solution across entire business model chain, modular design
8. **Can we increase?** Add distinctive features to have competitive advantage

Conclusion

Managing projects is a difficult exercise, with many constraints that have to be taken care of. Managing new product developments, especially when the innovation content is high, is a perilous exercise!

To succeed in your future endeavors, a necessary but not sufficient prerequisite is to master the basics of project management methodology!