Economic Considerations for RFID-Systems: From Application Ideas to running practical Applications

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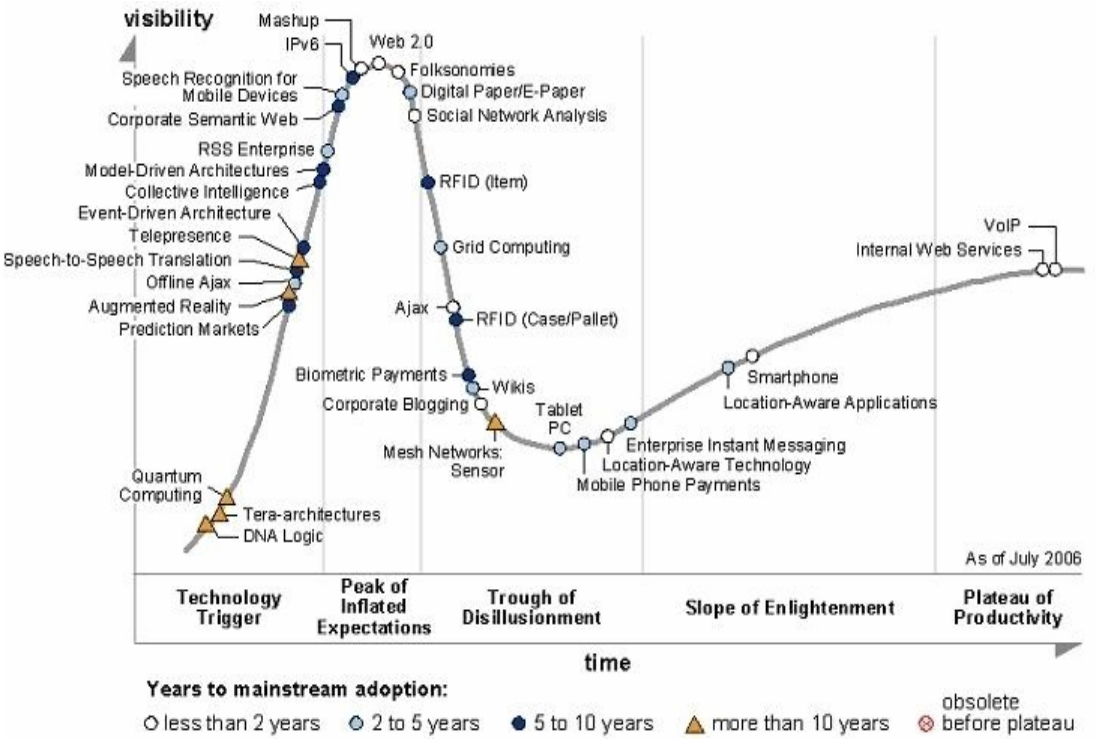
How far away is RFID from comprehensive Implementation?
Gartner‘s Point of View – The most recent »Gartner Hype Cycle«



- The user-market does not really know enough about the basic functionality and the typology of RFID-products
- Limits of the different types of RFID are often not sufficiently transparent to the user
- Benefits of the technology are therefore often overestimated and not verified in practice
- Rough and incomprehensive profitability analysis often come to a wrong solution

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What is the Idea of a Profitability Analysis?
Short Description of the basic Concept behind the Problem

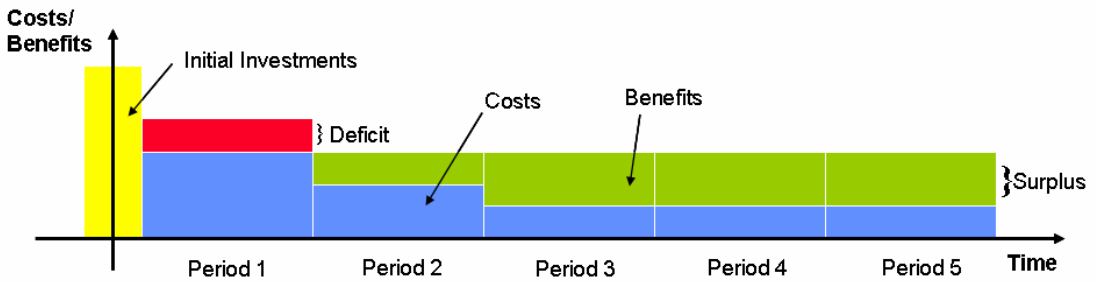
Comprehensive information about costs and benefits of an investment are reduced to one or more parameters in order to support management decisions

From a birds eye view an easy thing to do

but

the details are sometimes really challenging!

- Implementation starts with a large investment in hardware, software etc.
- During operation other costs for replacements, software updates, maintenance etc. arise.
- After a while benefits exceed the costs and generate a surplus
- If the accumulation of initial investments, operating costs and benefits becomes positive → profitability



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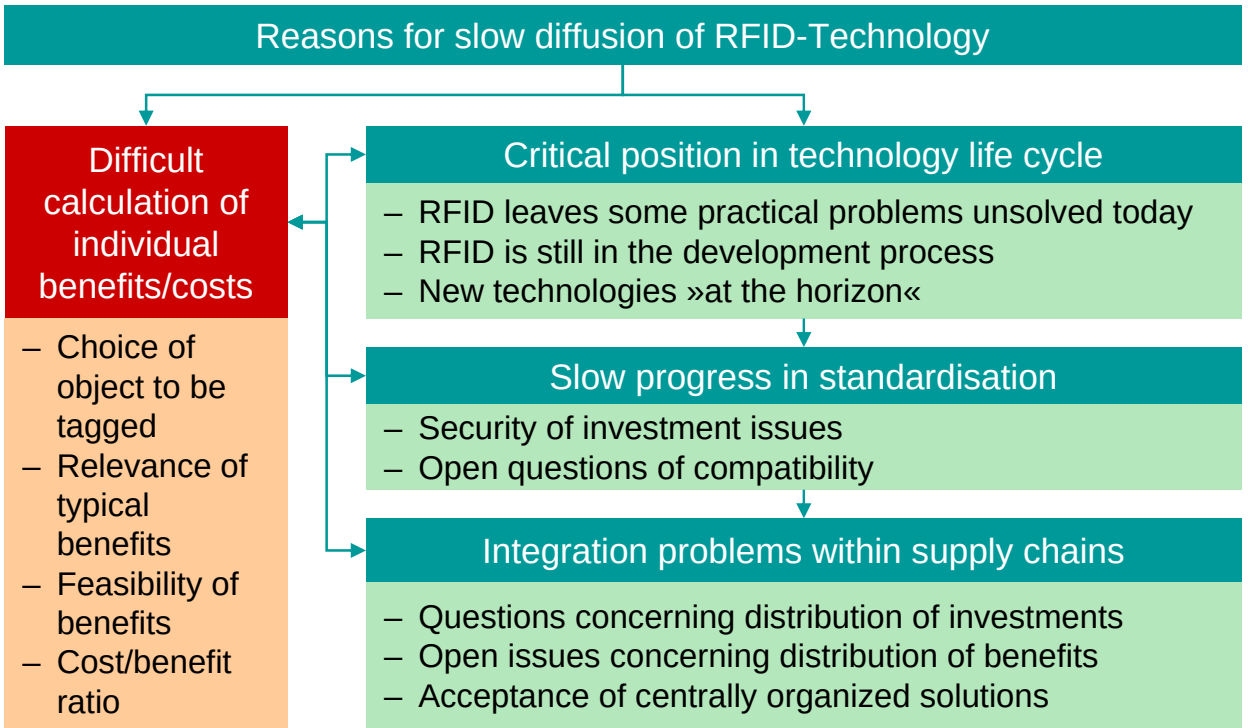
What makes the ecomomical Evaluation of RFID so difficult?
Four main Reasons for slow Market Penetration

A comprehensive Survey on existing evaluation methods shows that there is none which is able to handle RFID technology

That means that the »best fit«-method has to be identified and embedded into an evaluation procedure that takes into account all RFID-specific requirements



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What are the RFID-specific Requirements?
Basis for Evaluation of the »best fit« Assessment Method

RFID-specific requirements can be deduced from theory and/or from experiences made in consulting projects

The list on the right shows requirements which are important from the Fraunhofer ATL point of view (completeness can not be guaranteed)

- RFID implementation requires complemantary innovations → »consideration of complex cost structures«
- Due to »infrastructural« characteristics benefits show up indirectly → »consideration of indirect benefits«
- A large part of benefits can not be quantified → »consideration of qualitative aspects«
- Some of the benefits come up with a certain probability → »evaluation of risks and probabilities«
- Benefits differ heavily from company to company → »Flexibility and adaptability«
- The position within the technology life cycle requires → »consideration of dynamic developments«
- Due to the degree of innovation the method has to be convincing → »transparency and resilience of results«
- Due to the indicessiveness of potential users the method has to be simple → »easy-to-use method«

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What are the RFID-specific Requirements?
Relative importance of Requirements from a »subjective« Point of View

Nr.	Requirements	Weight
1	Consideration of qualitative aspects	20,31%
2	Transparency and resilience of results	18,75%
3	Consideration of indirect benefits	17,19%
4	Consideration of complex cost structures	10,94%
5	Evaluation of risks and probabilities	9,38%
6	Easy to use	9,38%
7	Consideration of dynamic developments	7,81%
8	Flexibility and adaptability	6,25%

	Consideration of indirect benefits	Flexibility and adaptability	Consideration of dynamic developments	Consideration of complex cost structures	Consideration of qualitative aspects	Evaluation of risks and probabilities	Easy to use	Transparency and resilience of results	Σ	Weight
Consideration of indirect benefits	0,5	1,0	1,0	0,5	0,5	0,5	1,0	0,5	5,5	17,19%
Flexibility and adaptability	0,0	0,5	0,5	0,0	0,0	0,5	0,5	0,0	2,0	6,25%
Consideration of dynamic developments	0,0	0,5	0,5	0,5	0,0	0,5	0,5	0,0	2,5	7,81%
Consideration of complex cost structures	0,5	1,0	0,5	0,5	0,0	0,5	0,5	0,0	3,5	10,94%
Consideration of qualitative aspects	0,5	1,0	1,0	1,0	0,5	1,0	1,0	0,5	6,5	20,31%
Evaluation of risks and probabilities	0,5	0,5	0,5	0,5	0,0	0,5	0,0	0,5	3,0	9,38%
Easy to use	0,0	0,5	0,5	0,5	0,0	1,0	0,5	0,0	3,0	9,38%
Transparency and resilience of results	0,5	1,0	1,0	1,0	0,5	0,5	1,0	0,5	6,0	18,75%
Gesamt									32,0	100,00%

- Half Matrix Technique has been used to assess the relative importance of the different requirements
- No objective method existing which helps to asses the requirements
- Transparency of method counts in that case

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Which Methods for economical Evaluation are available?
Overview of Economic Methods for Supporting Decision Processes

Methods for Comparison						
Methods for Investment Calculations						
	Static Investment Calculations	Cost Compare Analysis	Profit Compare Analysis	Return on Investment	Amortization Calculation	
	Dynamic Investment Calculations	Net Present Value	Annuity Method	Internal Rate of Return		
Multi dimensional Methods		Dual Method	Value Benefit Analysis	Advanced Efficiency Analysis		
Specialized Methods						
	IT-oriented Methods	Times Saving Times Salary Model (TSTS)				
	Controlling oriented Methods	Activity Based Costing	Target Costing			
	Strategy oriented Methods	McFarlan & McKenney	Parsons			
Methods for Decission Support						
Operations Research Models		Linear Programming	Transport.-Algorithm	Netplan-Technique	User Models	Sequence Models
Decisison Theory						
	Methods for Uncertainty	MaxiMax-Criteria	MaxiMin-criteria	LaPlace-Criteria	Hurwitz-Criteria	Sav.-Nieh.-Criteria
	Methods for Risk	μ-Criteria	σ-Criteria	Bernoulli-Criteria		
Prognosis						
Methods for Prognosis		Portfolio-Technique	Early Warning Systems	Scenario Technique		
Matematical Statistical Methods		Linear Regression	Trend Analysis	Indexes		

- Prognosis methods help to define probable future scenarios which are the background for comparison of different investment alternatives
- Methods for comparison provide performance indicators (like productivty, amortization time etc.) which enable management decisions (one most probable scenario given)
- Methods for decision support are helpful if more scenarios are equally probable and if the decision for or against an alternative changes depending on the scenario

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Which Methods for economical Evaluation are available?
Evaluation of existing Methods

Nr.	Methods	Weight
1	Advanced Efficiency Analysis (AEA)	4,00
2	Value Benefit Analysis (VBA)	2,81
3	Net Present Value (NPV)	2,59
4	Activity Based Costing (ABC)	2,44
5	Return of Investment (ROI)	2,27
6	Internal Rate of Return (IRR)	2,23
7	Times Saving Times Salary Model (TSTS)	2,20

Requirements / Method	Consideration of qualitative aspects	Transparency and recilience of results	Consideration of indirect benefits	Consideration of complex cost structures	Consideration of dynamic developments	Evaluation of risks and probabilities	Easy to use	Flexibility and adaptability	Result
Weight	20,31%	18,75%	17,19%	10,94%	7,81%	9,38%	9,38%	6,25%	
Return of Investment (ROI)	1	3	3	3	2	1	3	2	2,27
Times Saving Times Salary Model (TSTS)	2	2	4	1	2	1	2	3	2,20
Net Present Value (NPV)	1	3	3	3	5	3	2	2	2,59
Internal Rate of Return (IRR)	1	2	2	3	5	3	2	2	2,23
Activity Based Costing (ABC)	3	3	2	2	3	2	1	3	2,44
Value Benefit Analysis (VBA)	5	3	2	1	2	1	3	4	2,81
Advanced Efficiency Analysis (AEA)	5	4	4	4	5	4	1	4	4,00

- VBA, NPV, ABC, ROI, IRR and TSTS do rarely meet requirements
- Large gap between AEA and all the other evaluation methods
- RFID should therefore handled with AEA (which – to be honest – is a combination between the other methods

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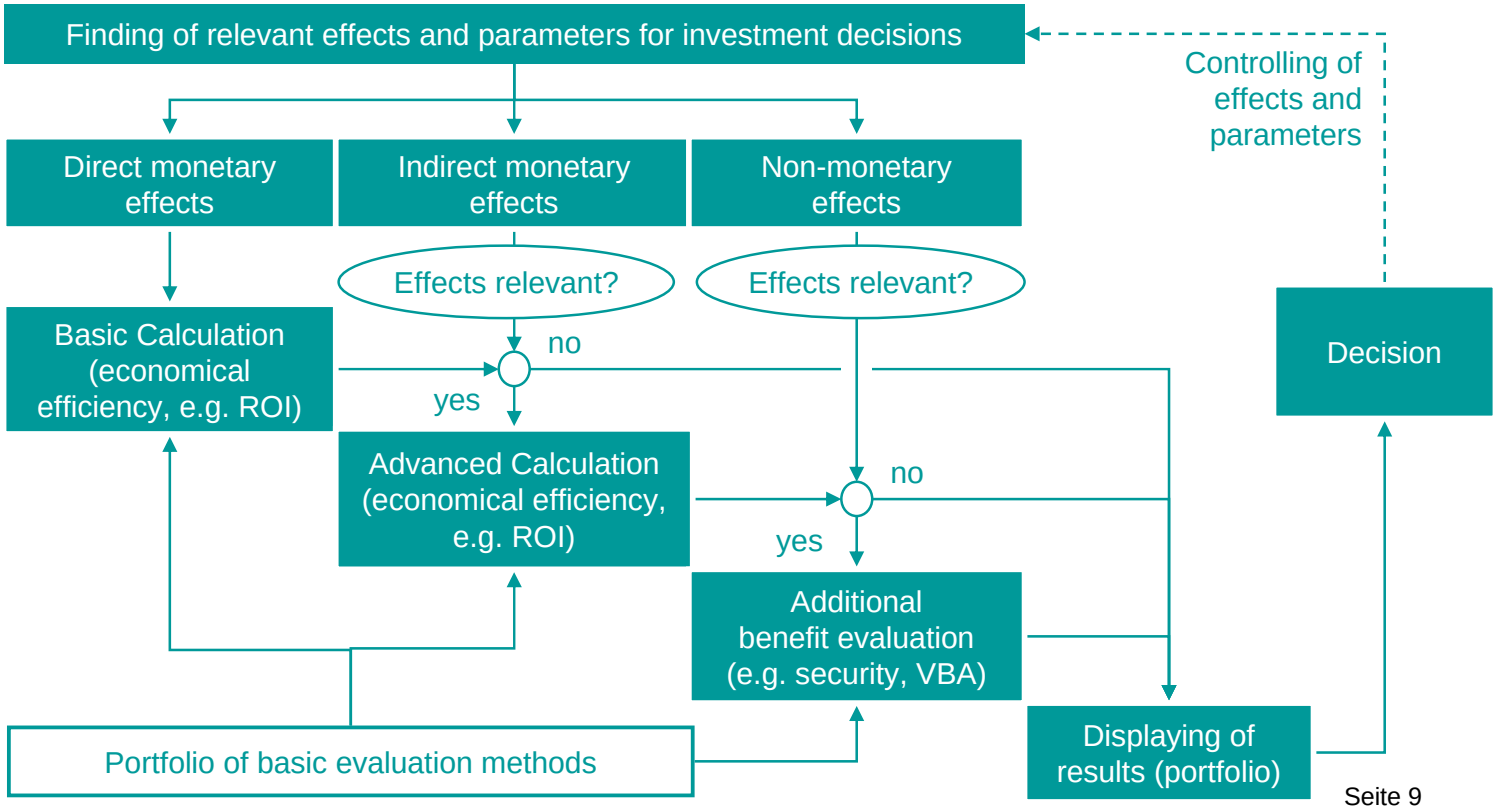
How does the Advanced Efficiency Analysis Method work?
AEA as a Framework for a comprehensive Evaluation

AEA is a combination of existing methods which clearly shows the benefits of different types of effects

Results have to be compared to the status-quo as a reference point or to another technological alternative



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How could or should a proper Evaluation Procedure look like? Overview on the more important Steps

- Definition of a scenario: Which objects should be tagged in order to realise as much benefits as possible?
- Process Analysis: How do the logistic processes which are relevant for these objects look like?
- Definition of I-Points: Where are informations points needed in order to realise the identified benefits?
- Technological Feasibility: Does the market provide tags or tag types which meet the different requirements?
- Process Design: How does the process look like after implementation of RFID-Technology?
- System Design and Cost analysis: What ar the costs of a system that realises the expected benefits?
- Benefit Analysis and evaluation: Does the implementation make sense from the economic point of view?

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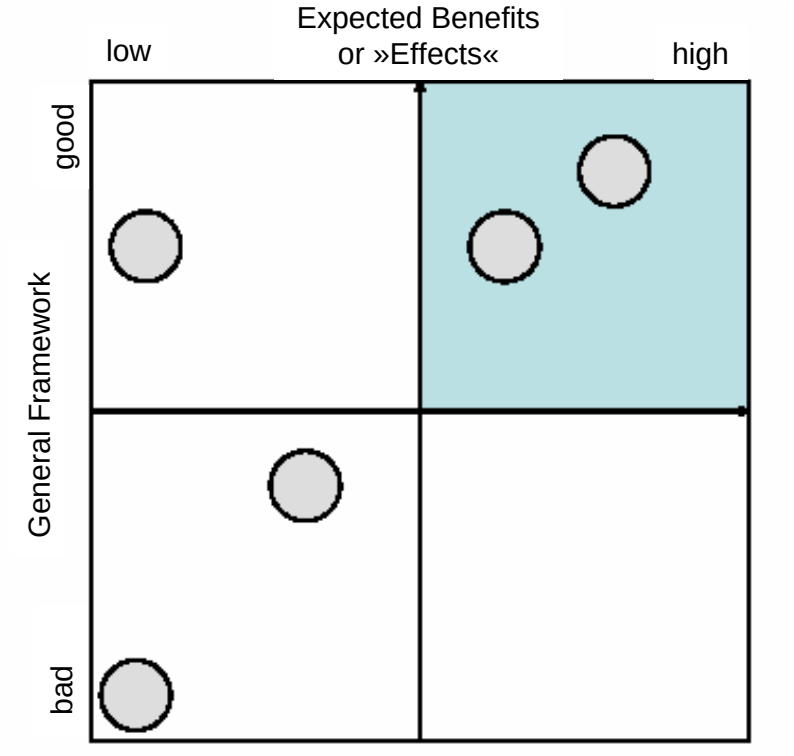
Which Objects should or could be tagged with RFID-Products? Functionality of Products depends on Type of Object

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation



- Main goal is identification of objects offering high benefits.
- »Tree of benefits« can be used to identifiy typical benefits linked to the different objects.
- Different criteria used for evaluation of framework for implementation.
- Result of portfolio analysis is a prioritized list of objects.
- Challenge is identification of objects or clusters that have to be taken into account.

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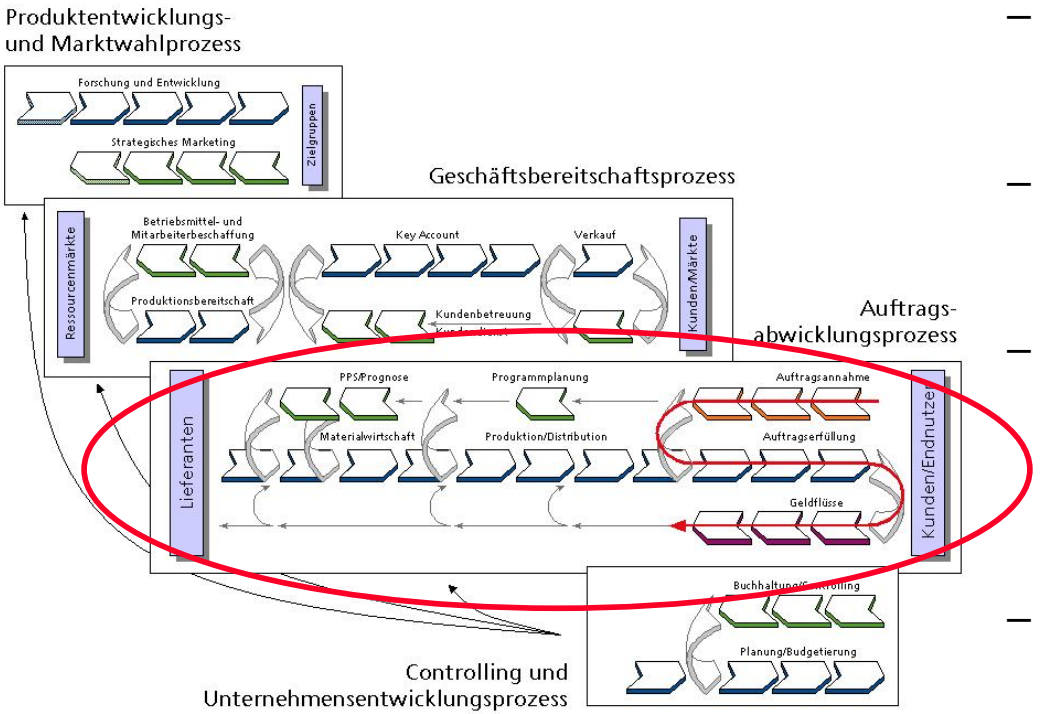
How do the relevant logistical Processes look like? Benefits can be allocated to different Process Steps

- Definition of Scenario
- **Process Analysis**
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation



- In the first step analysis from the companies point of view
- In a second life cycle management issues can be handled
- Focus on order to payment process since largest part of benefits will be realized within the O2P-process.
- Focus on material and information flow.

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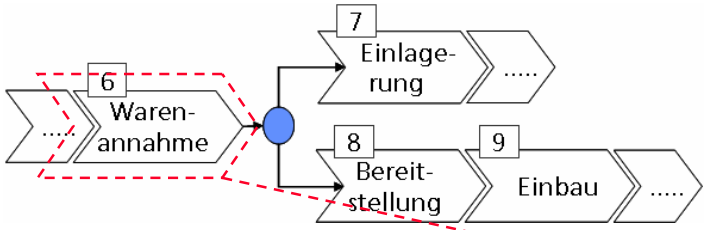
How do the relevant logistical Processes look like?
Challenge is to describe Processes on the right Level of Detail

- Definition of Scenario
- **Process Analysis**
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation



Ausschnitt Prozessplan

		Aktuelle Situation			
Nr.	Zuständig	Prozessschritt und Aktivität	Hilfsmittel / Mitarbeiter	Zeit	Kosten
6	**Abt. A**	**Warenannahme**			
6.1	Abt. A	Aktivtät 1	MA X	3 min	.... €
6.2	Abt. A	Aktivtät 2	MA X	5 min	
6.3	Abt. A	Aktivtät 3	MA X	...	
6.4	Abt. A	Aktivtät 4			
6.5	Abt. A	.....			
6.6	Abt. A				
6.7	Abt. A				
6.8	Abt. A				

- Top-down method coming from a global model of a companies operations.
- Processes have to be analysed down to work station level (goods stop flowing here).
- Descripton in form of process flows with existing modelling tools (no ARIS necessary!).
- Detailed description of activities of each process step (physical activities and information flows).
- (Completion with activity costs or cost/time and duration).

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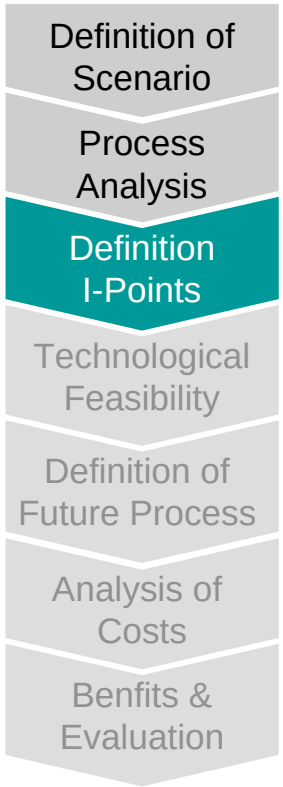
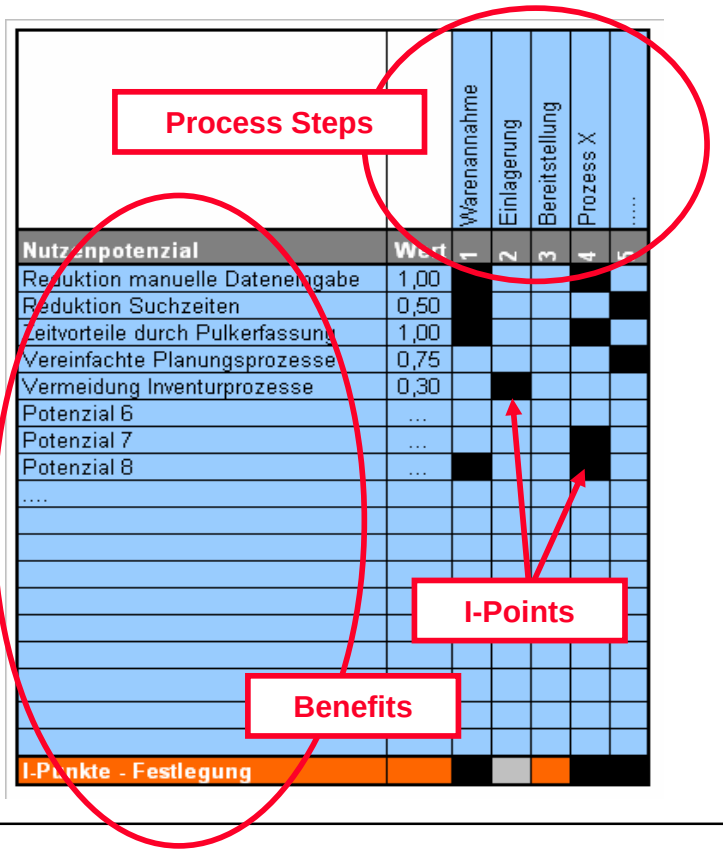
Where are I-points needed in Order to realise the identified Benefits? Technological Requirements are defined here





- Usage of process-benefit-matrix for identification of information points.
- Discussion of each and every matrix element with project team.
- If time and/or budget is limited focus on the more important benefits (»quick an easy to achieve wins«).
- Description of I-point
  - process and type of objects,
  - consolidation degree of objects,
  - basic use cases,
  - type of reader etc.

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Are Tags or Tag Types available which meet the different Requirements? Challenging technological Feasibility Study

- Definition of Scenario
- Process Analysis
- Definition I-Points
- **Technological Feasibility**
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation

Nr.	Kriterium		Anforderungen	Smartlabel
1	Basisfunktionen	Identifikation	ja	ja
		Datenspeicherung	ja	begrenzt
		Sensorik	Intrusion Detection	nein
		Displayfunktion	nein	nein
2.	Geometrie	Form	Smartlabel	ja
		Fläche	keine Einschränkung	Labelformat
		Höhe	< 1mm	kleiner 1 mm
3.	Substrat	Flexibilität	nicht unbedingt	ja
4.	Mikrochip	Speicherkapazität	EPC/Zusatzdaten	EPC
		Anzahl Zyklen	<100	fast unbegrenzt
5.	Luftschnittstelle	EPC-Kompatib.	ja	ja
		Datenübertragung	WR	WR
		Frequenz	keine Einschränkung	13,56 MHz/868 MHz
		Reichweite R/W	wenige Meter	3 bis 7 m
		Zul. v-relativ	Schrittgeschw.	k.A.
		Materialdurchdr.	Diverse Stoffe	Org. Mat. kritisch
		Datenrate	wenige kBit/sec	einige kBit/sec
		Multitagging	ja, > 100 Tags/sec	ja, > 100 Tags/sec
6.	Datensicherheit	Passwortschutz	ja	ja
		Lock-Funktion	ja	ja
		Verschlüsselung	nein	nein
7.	Umgebungsbed.	Zul. T-Bereich	-20 bis +40 °C	-20 bis +40 °C
		Res. Feuchtigkeit	nein	nein
		Res. Reinigungsm.	nein	nein
		Funktion auf Metall	nein	nein
8.	Sonstige	Energieversorgung	passiv	passiv
		Lebensdauer	wenige Wochen	wenige Wochen
		reis		25 ¢ Cent

Performance Characteristics | **Require-ments** | **Product Profiles**

- Definition of requirement profiles for each I-poínt.
- Consolidation of one reference profile.
- Comparison with performance profiles of existing products.
- In case of gaps redesign of requirement profiles and/or technology prognosis.
- Decision concerning continuation of the project.
- In parallel technological tests at critical I-points often make sense.

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How does the Process look like after implementation of RFID? Adaptation of the already existing Process Plan!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- **Definition of Future Process**
- Analysis of Costs
- Benfits & Evaluation

Ausschnitt Prozessplan									
		Aktuelle Situation				Zukünftige Situation			
Nr.	Zuständig	Prozessschritt und Aktivität	Hilfsmittel / Mitarbeiter	Zeit	Kosten	Prozessschritt und Aktivität	Hilfsmittel / Mitarbeiter	Zeit	Zusatzkosten / Kosteneinsparungen
6	Abt. A	Warenannahme							
6.1	Abt. A	Aktivtät 1	MA X	3 min	2,10 €	Entfällt vollständig	-/-	3 min	- 2,10 €
6.2	Abt. A	Aktivtät 2	MA X	5 min	3,50 €				
6.3	Abt. A	Aktivtät 3	MA X	...					
6.3.1	Abt. A					Aktivität.3.1	MA Y	1 min	+ 0,70 €
6.4	Abt. A	Aktivtät 4							
6.5	Abt. A	.....							
6.6	Abt. A								
6.7	Abt. A								
6.8	Abt. A								
6.9	....								
	Gesamt	Wareneingang							-1,40 €

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What are the Costs of a System that realises the expected Benefits? Complex and time-dependent Cost Structures!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- **Analysis of Costs**
- Benfits & Evaluation

Costs	Implementation			Operation			
	Preparation	Investment	Ramp Up	Period 1	Period 2	Period 3	Period 4
Costs for feasibility study							
Procurement of tags							
Procurement of readers and other hardware							
Procurement and adaptation of middleware							
Procurement and adaptation of application software							
Efforts for staff training							
Efforts for motivation and persuasion							
Costs for project and risk management							
Costs for process adaptation and implementation							
Personal costs for usage							
Personal costs for maintenance							
Personal costs for system adaptation							
Communication and energy costs							
Additdional cost for handling (e.g. tag attachment)							
Schrinkage of tags							
Depreciation of investment							
Costs of equity							
Opportunity costs							
Personal costs of project attendance							
Failure costs							

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What are the quantitative and qualitative Benefits?
Direct Benefits are quantified using the Process Plan!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation

Ausschnitt Prozessplan									
		Aktuelle Situation				Zukünftige Situation			
Nr.	Zuständig	Prozessschritt und Aktivität	Hilfsmittel / Mitarbeiter	Zeit	Kosten	Prozessschritt und Aktivität	Hilfsmittel / Mitarbeiter	Zeit	Zusatzkosten / Kosteneinsparungen
6	Abt. A	Wareannahme							
6.1	Abt. A	Aktivtät 1	MA X	3 min	2,10 €	Entfällt vollständig	-/-	3 min	- 2,10 €
6.2	Abt. A	Aktivtät 2		5 min	3,50 €				
6.3	Abt. A	Aktivtät 3		...					
6.3.1	Abt. A					Aktivität.3.1	MA Y	1 min	+ 0,70 €
6.4	Abt. A	Aktivtät 4							
6.5	Abt. A	.....							
6.6	Abt. A								
6.7	Abt. A								
6.8	Abt. A								
6.9	....								
	Gesamt	Wareneingang							-1,40 €

deleted activity

additional activity

benefit

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What are the quantitative and qualitative Benefits?
Indirect Benefits can be quantified using Side Calculations!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
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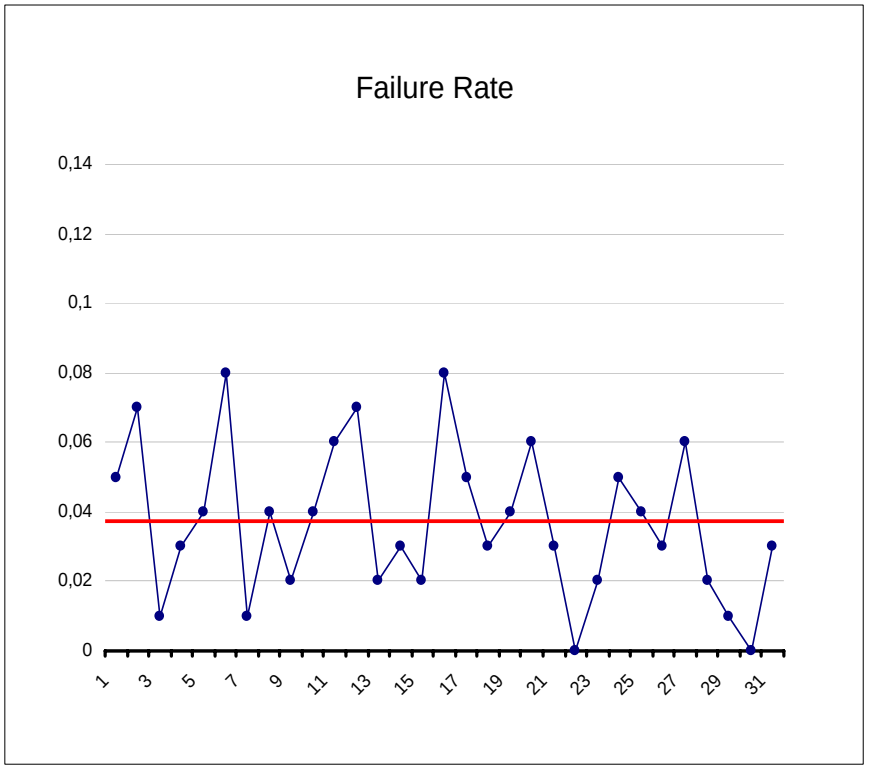

- Direct effects can be quantified by comparison between todays and tomorrows processes
- For quantification of indirect effects side calculations are necessary
- Normally additional information has to be gathered in the company
- Sometimes special mathematic algorithms are needed (e.g. assurance mathematics for unlikely and costly events)

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What are the quantitative and qualitative Benefits?
Examples for direct and indirect RFID-related Benefits!

- Definition of Scenario
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- Definition of Future Process
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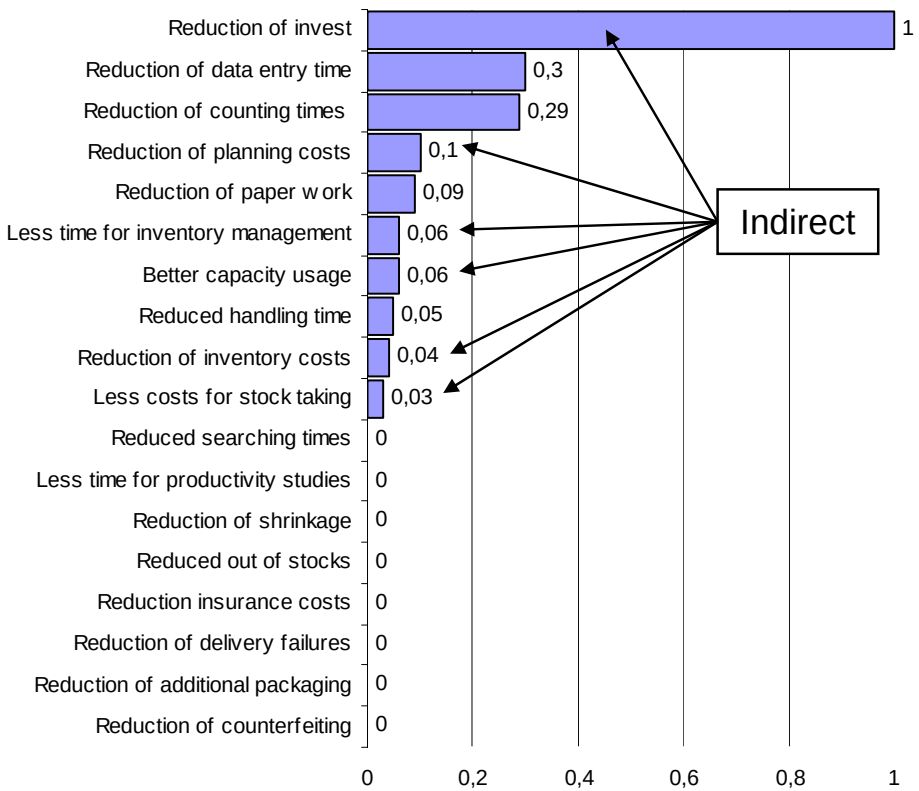
- Benfits & Evaluation



- Example on the left side from the automotive industry (1. Tier, Container Management)
- Large part of benefits indirect (and therefore difficult to handle)
- Figures are (like costs before) input for the first two steps of the AEA (ROI, NPV, IRR etc.)
- Fact that benefits are time-dependent has to be taken into account

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What are the quantitative and qualitative Benefits?
Qualitative Benefits can be handled with the Value Benefit Analysis!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- Benfits & Evaluation

Nr.	Qualitative Benefits	Weight
1	Competitive capacity	0,18
2	Decrease of lead times	0,17
3	Increase of data & process quality	0,17
4	Increase of process transparency	0,13
5	Sustainability	0,11
6	Increase of customer satisfaction	0,08
7	Improvement of SCI capabilities	0,07
8	Simplifying of processes and handling	0,04
9	Enabling of RFID-based VA-services	0,04

	Competitive capacity	Decrease of lead times	Increase of data & process quality	Increase of process transparency	Sustainability	Improvement of SCI capabilities	Increase of customer satisfaction	Simplifying of processes and handling	Enabling of RFID-based VA-services	Σ	Weight
Competitive capacity	0,5	1,0	0,5	1,0	0,5	1,0	1,0	0,0	1,0	6,5	18,31%
Decrease of lead times	0,0	0,5	0,5	1,0	1,0	1,0	1,0	0,0	1,0	6,0	16,90%
Increase of data & process quality	0,5	0,5	0,5	1,0	1,0	0,5	1,0	0,0	1,0	6,0	16,90%
Increase of process transparency	0,0	0,0	0,5	0,5	1,0	0,5	1,0	0,0	1,0	4,5	12,68%
Sustainability	0,5	0,0	0,0	0,0	0,5	1,0	1,0	0,0	1,0	4,0	11,27%
Improvement of SCI capabilities	0,0	0,0	0,0	0,5	0,0	0,5	0,0	0,5	1,0	2,5	7,04%
Increase of customer satisfaction	0,0	0,0	0,0	0,0	0,0	1,0	0,5	0,5	1,0	3,0	8,45%
Simplifying of processes and handling	0,0	0,0	0,0	0,0	0,0	0,5	0,5	0,5	0,0	1,5	4,23%
Enabling of RFID-based VA-services	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,5	1,5	4,23%
Gesamt										35,5	100,00%

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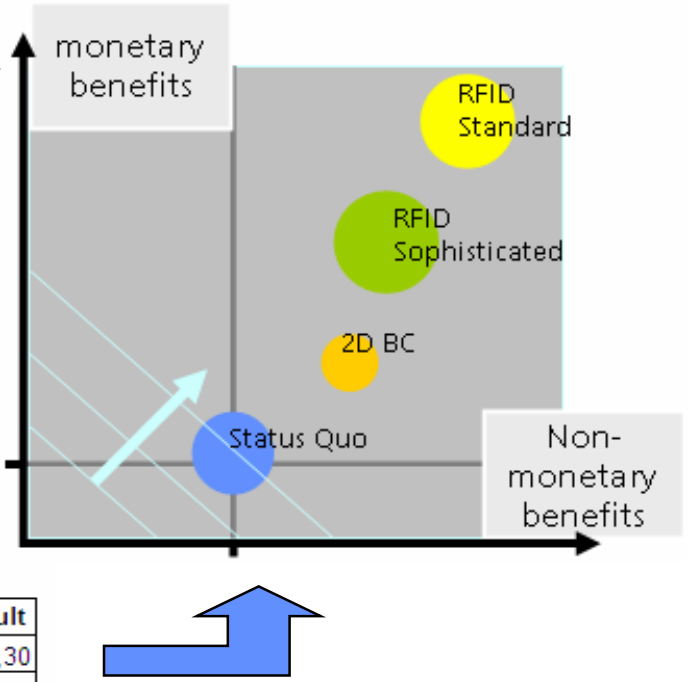
Which technological Alternative should be chosen?
Comparision using Portfolio Analysis in Combination with AEA!

- Definition of Scenario
- Process Analysis
- Definition I-Points
- Technological Feasibility
- Definition of Future Process
- Analysis of Costs
- **Benfits & Evaluation**

Qualitative Benefits / Weight	Competitive capacity 18,00%	Decrease of Lead Times 17,00%	Increase of data & process quality 17,00%	Increase of process transparency 13,00%	Sustainability 11,00%	Increase of customer satisfaction 8,00%	Improvement of SCI capabilities 7,00%	Simplifying of processes and handling 4,00%	Enabling of RFID-based VA-services 4,00%	Result
Alternative										
Status Quo	1	1	1	2	2	1	2	1	1	1,30
2D-Barcode	1	2	2	2	4	2	3	1	1	2,01
RFID-Proprietary	3	4	4	4	3	2	3	4		
RFID-Standard	5	4	4	3	5	5	5	4		



Nr.	Alternative	Non-Financial Benefit Indicator
1	RFID-Standard	4,31
2	RFID-Proprietary	3,48
3	2D-Barcode	2,01
4	Status Quo	1,30

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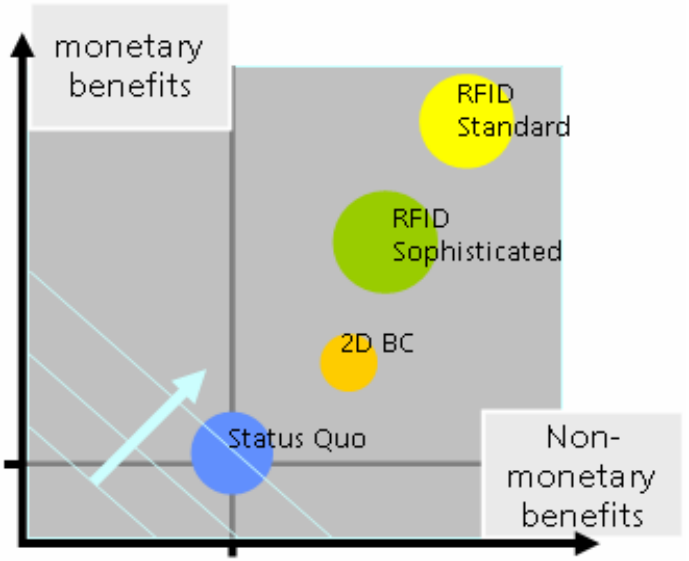
Technological Alternative	Method	Total	Period 1	Period 2
Status Quo	ROI	0,00%	0,00%	0,00%
	ROI Average Annual	0,00%		
	Net Present Value	42,23	-10,00	3,00
	Total Cost of Ownership	127,00	127,00	127,00
2D-Barcode	ROI	247,28%	67,38%	96,34%
	ROI Average Annual	49,46%		
	Net Present Value	68,00	-68,00	
	Total Cost of Ownership	198,00	198,00	
RFID-Proprietary	ROI	247,28%	49,46%	91%
	ROI Average Annual	49,46%		
	Net Present Value	335,24	-105,00	2,00
	Total Cost of Ownership	95,00	95,00	5,00
RFID-Standard	ROI	183,80%	36,00%	72,00%
				4,00
			135,00	135,00

Nr.	Alternative	Financial Benefit Indicator
1	RFID-Standard	5,00
2	RFID-Proprietary	3,50
3	2D-Barcode	2,13
4	Status Quo	0,75



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The Fraunhofer IIS by Numbers

- Founded 1985
- Branch offices in Erlangen, Fürth, Nürnberg, Dresden, großer Kornberg
- Ca. 480 Researchers/Staff
- Turnover approximately 56 Million Euro
- 20% public funding and 80% via projects
- www.iis.fraunhofer.de

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Business Fields of Fraunhofer IIS

- IC-design and design automation
- Imaging systems and quality assurance
- Digital broadcasting systems
- Embedded Systems
- Audio/video/multimedia
- Medical technologies
- Logistics and transport
- Navigation and robotics

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Activities with Relation to RFID & Smart Items within Different Departments of the Institute

- Optimization of RFID tags, e.g. antenna design, metal mount function, energy consumption etc.
- Development of telemetry, sensor and wireless communication systems.
- Development of ad-hoc networks and sensor networks (hardware, protocols, software).
- Development of localization systems for tags and smart items (different methods).
- Technological and economical feasiblity studies for technolgy providers and users.
- Design and realisation of RFID application prototypes (tracking & tracing, theft prevention).

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Bundling of Competences and Activities within the »Engineering Centre for Smart Objects in Logistics«

- Research on Smart Object Technologies from a systems and problem point of view.
  - passive RFID,
  - active networked tags with sensors,
  - localization systems
- Main topics:
  - Service Design
  - Design of application systems
  - Technology assessment
  - Closing of technological gaps
- Cooperation with different technology providers and users.

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