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Compact 

TECHNOLOGY TRANSFER FOR THE XLS-XFEL

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Strategy & Methodology

To be followed



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Complexity of the CompactLight

Do we try to push the “entire thing” or bits and pieces - what is most likely to succeed?

Definition of the project results/assets
(what will be exploited?)

Matching exploitable results with WPs and project objectives

Type of Project Result

- New Knowledge
- Software or/and Hardware products
- Services, Methodologies

Decision on the exploitation strategy for each asset (how we are going to exploit it?)

Scientific Exploitation/ Further research

- Publications in media of general interest and academic journals
- Data
- Educational materials
- Research roadmaps

Purpose: **scientific, advancement of knowledge**

Standardization and Open Source Contribution

- Best practice guidelines
- Open Data
- Investigative reports
- Briefing materials
- Consultation reports
- Standards Guide
- Policy recommendations
- Codes of conduct

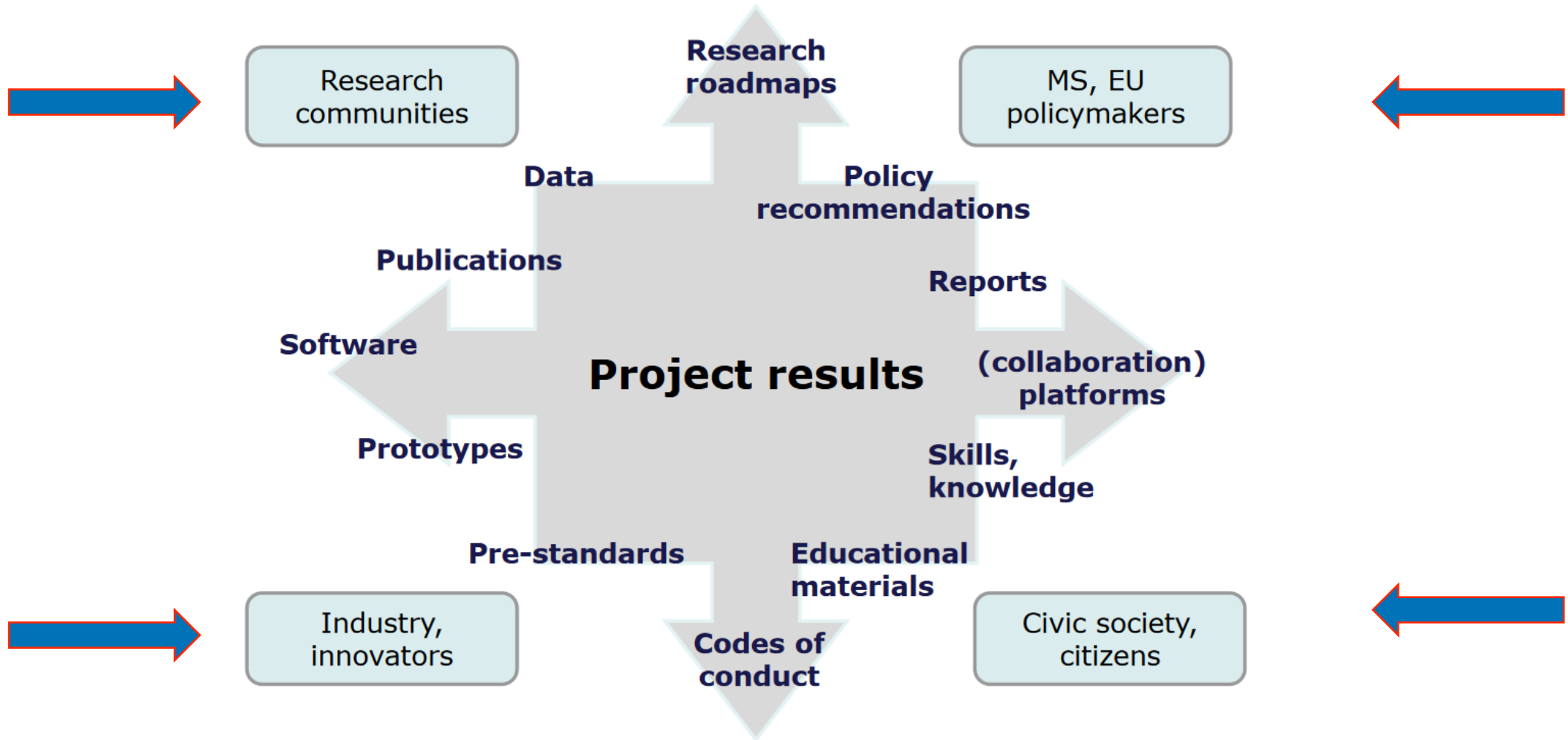
Purpose: **Industry, Societal, Political**

Commercial Exploitation (Technology Transfer or Creation of a Spin-off)

- Prototypes
- Software or hardware
- Services and Methodologies

Purpose: **Economic**

Identification of Potential Users and Stakeholders (who will benefit?)



Select a strategy for each Exploitable Result

«Divide & Conquer»

	Scientific Exploitation/ Further research	Standardisation & Open Source contribution	Commercial exploitation
Knowledge			
Software and/or hardware products		Productive4 Platform	
Services and methodologies			

How to identify the Exploitable Results, Strategy and Stakeholders



Exist in the individual deliverables

- The detailed description of each exploitable result will not be repeated in the Exploitation plan



Conduct Internal Workshops (Semi-structured Interviews or Focus Groups)

- with the representatives from WP
- via phone, skype or F2F meetings



Design a survey

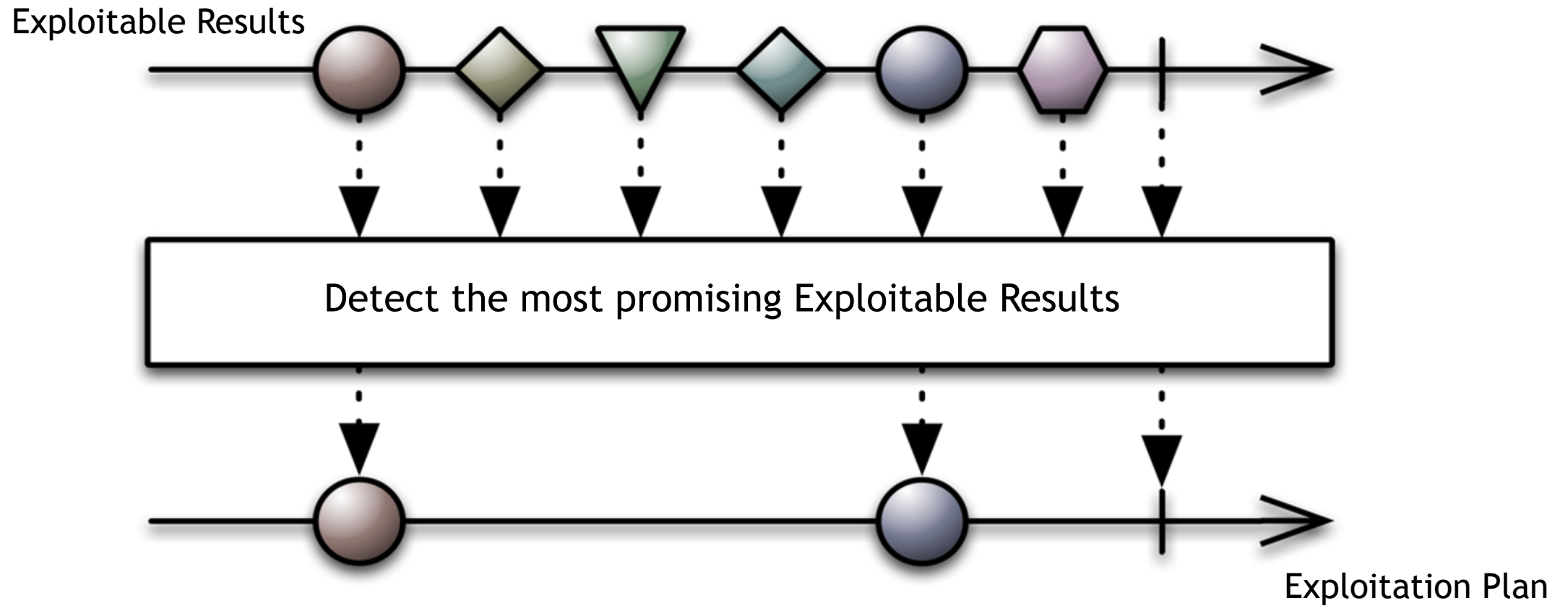
- Measure the perceptions of stakeholders or future users community
- Assess the exploitation potential of CompactLight results

Topics to be addressed during the internal workshops and the survey

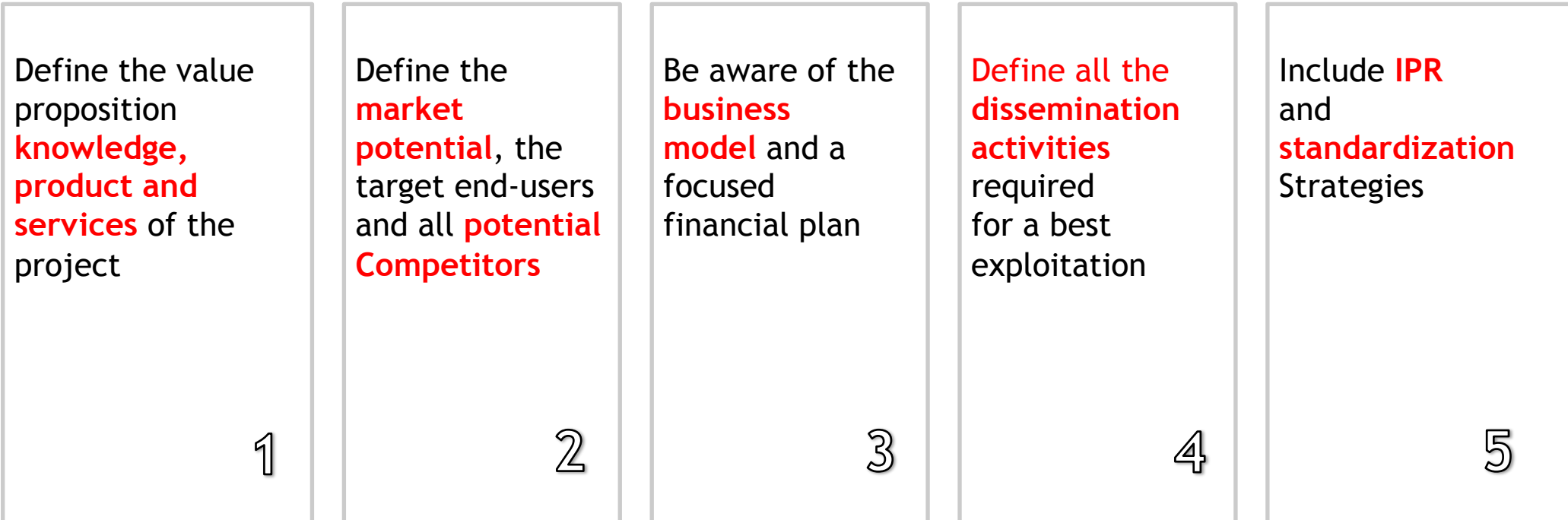
- **Type of result** (product, process, SW, service, etc.)
- **Innovation.** State of the Art exceeded
- **Benefits** (to customers, collaboration partners, public etc..)
- **Technology Readiness Level-TRL** and the progression up to TRL9 (*)
- **Technical challenges**
- **Time to Market**
- **Protection and Intellectual Property Rights-IPR** issues

(*) **TRL 9 (TRL Scale in Horizon 2020 and ERC)** - Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

What we wish to achieve?



THE EXPLOITATION PLAN: what steps should be included

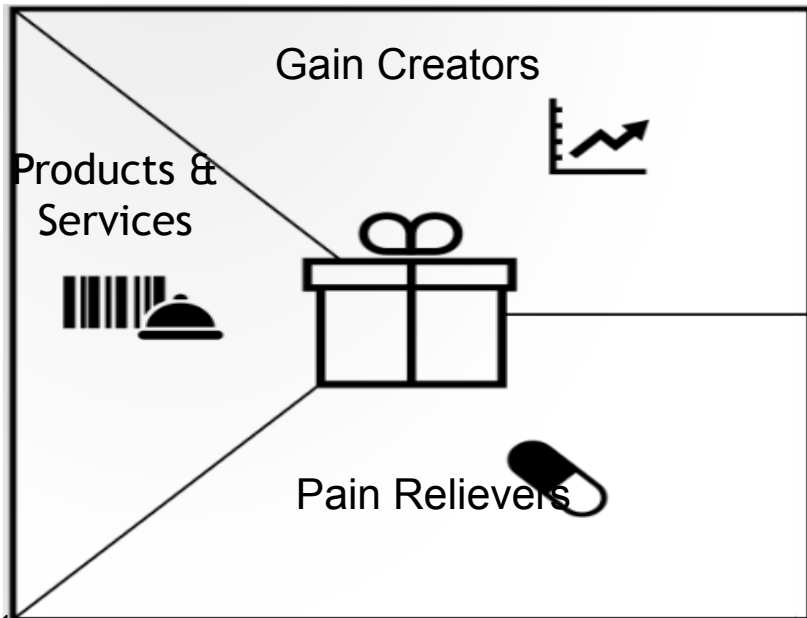





Step 1

Value Proposition Analysis

The customer and business value of Exploitable Results are investigated and measured

- Product and services
- Gain Creators : **create customer gains**
- Pain Relievers : **alleviate customer pains**



	<ul style="list-style-type: none">• Which one of your products and services customers really want?• Which ones they want most?
	<ul style="list-style-type: none">• Which one of your gain creators customers really need or desire?• Which ones they crave most?
	<ul style="list-style-type: none">• Which one of your pain relievers helps your customers with their headaches?• Which ones they long for most?

Step 2

Validation of the business opportunity: SWOT Analysis

Identify the Strengths, Weaknesses, Opportunities, and Threats of the research result/ knowledge output:

- What are the **strengths and weaknesses** of your business or potential business?
- Who are your **competitors** and what are their strengths and weaknesses?
- What is your **competitive advantage** over your competitors?

	Opportunities (external, positive)	Threats (external, negative)
Strengths (internal, positive)	Strength-Opportunity strategies Which of the company's strengths can be used to maximize the opportunities you identified?	Strength-Threats strategies How can you use the company's strengths to minimize the threats you identified?
Weaknesses (internal, negative)	Weakness-Opportunity strategies What action(s) can you take to minimize the company's weaknesses using the opportunities you identified?	Weakness-Threats strategies How can you minimize the company's weaknesses to avoid the threats you identified?

Source: Albert Humphrey,



■ SWOT: Strength - Weakness - Opportunity - Thread

Strength

- New design with improved specifications than existing facilities
- Active and broad collaboration with experience teams in the project
- Industrial partnership
- Scientific, Engineering, Finance & Economical academic partnership
- Less expensive final product

Weakness

- Many technological option(s) to various parts of our project, No yet decided the final option
- Effort to cover many sub-areas of X-ray production



SWOT: Strength - Weakness - Opportunity - Thread

Opportunity

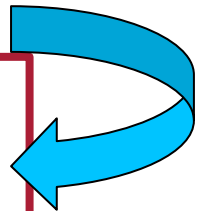
- Large areas without light source in Europe and elsewhere for implementation of our final product
- Cooperation development with institutions and countries to commercialize our product
- Future member of the XFEL network

Thread

- Parallel XFEL projects under current development or operation
- Different technology projects providing S-/C-band X-rays or some of them

Recommendation

- It is strongly recommended the CompactLight collaboration to focus, mainly, to the option(s) and deliverables is obliged to submit to the EC funding agency as in the approved proposal

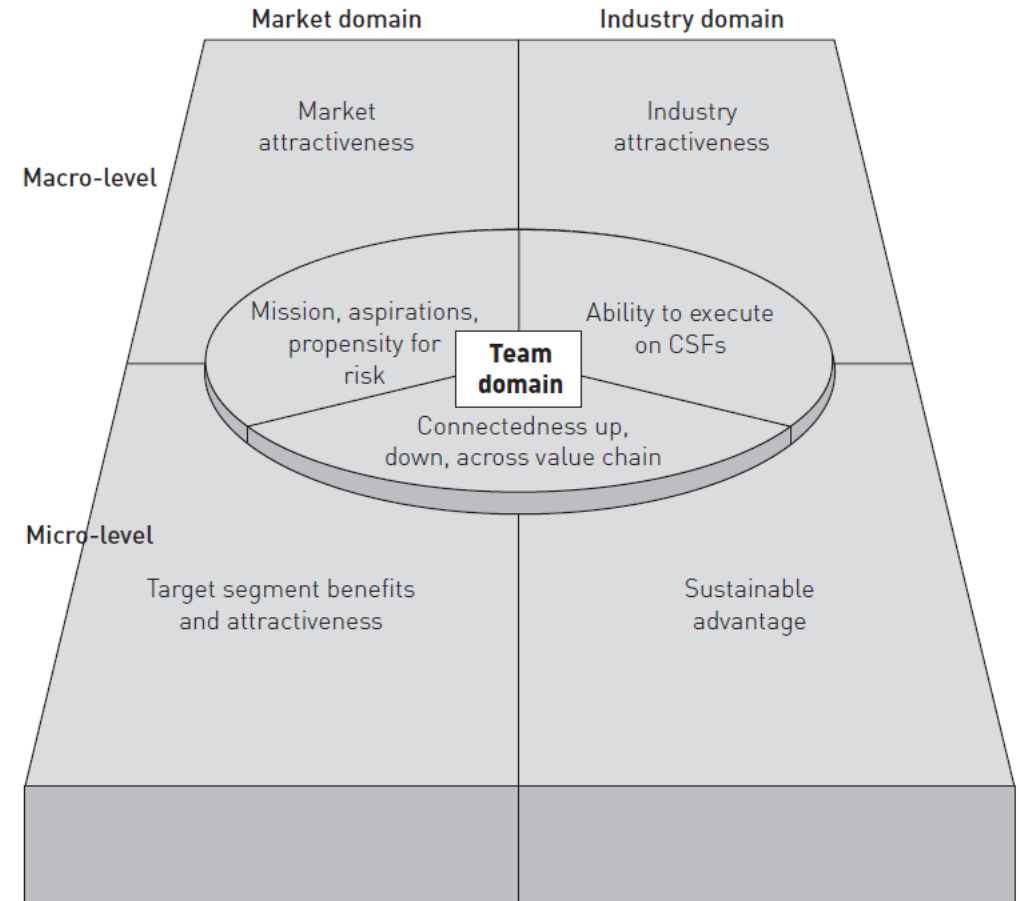


Step 2

Market and Industry Research

The Seven Domain Model

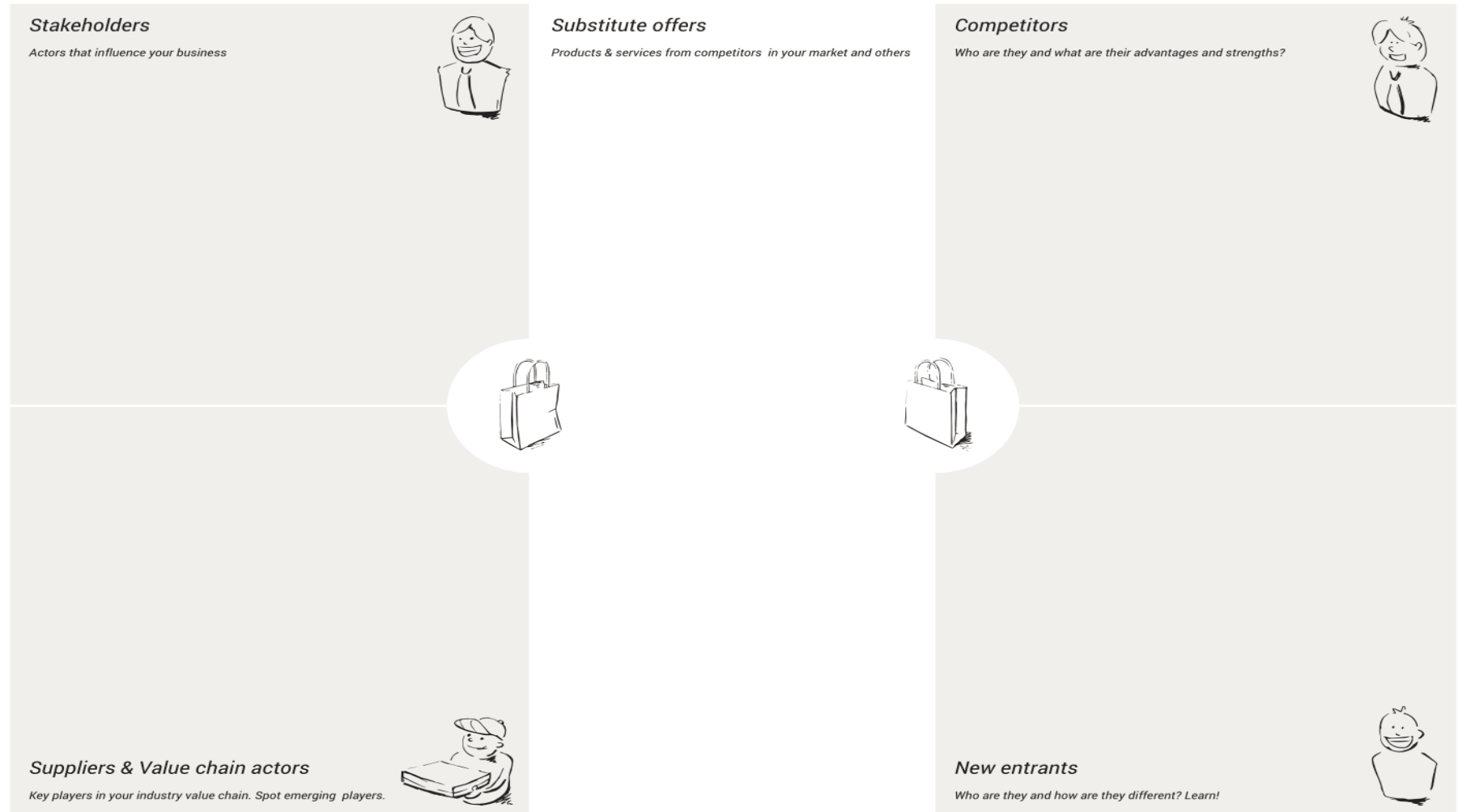
- The seven domain Framework Toolkit by Mullins (2003) provides the answer IF our product is attractive to market / industry
- Obtain information about the current market by researching trends and analyzing the competition.
 - What is the estimated size of the market for the product/service?
 - What is the projected market share?
 - Is the current market attractive for the product/service?
 - Are there any predictions for future trends?
 - Which are the existing business models?



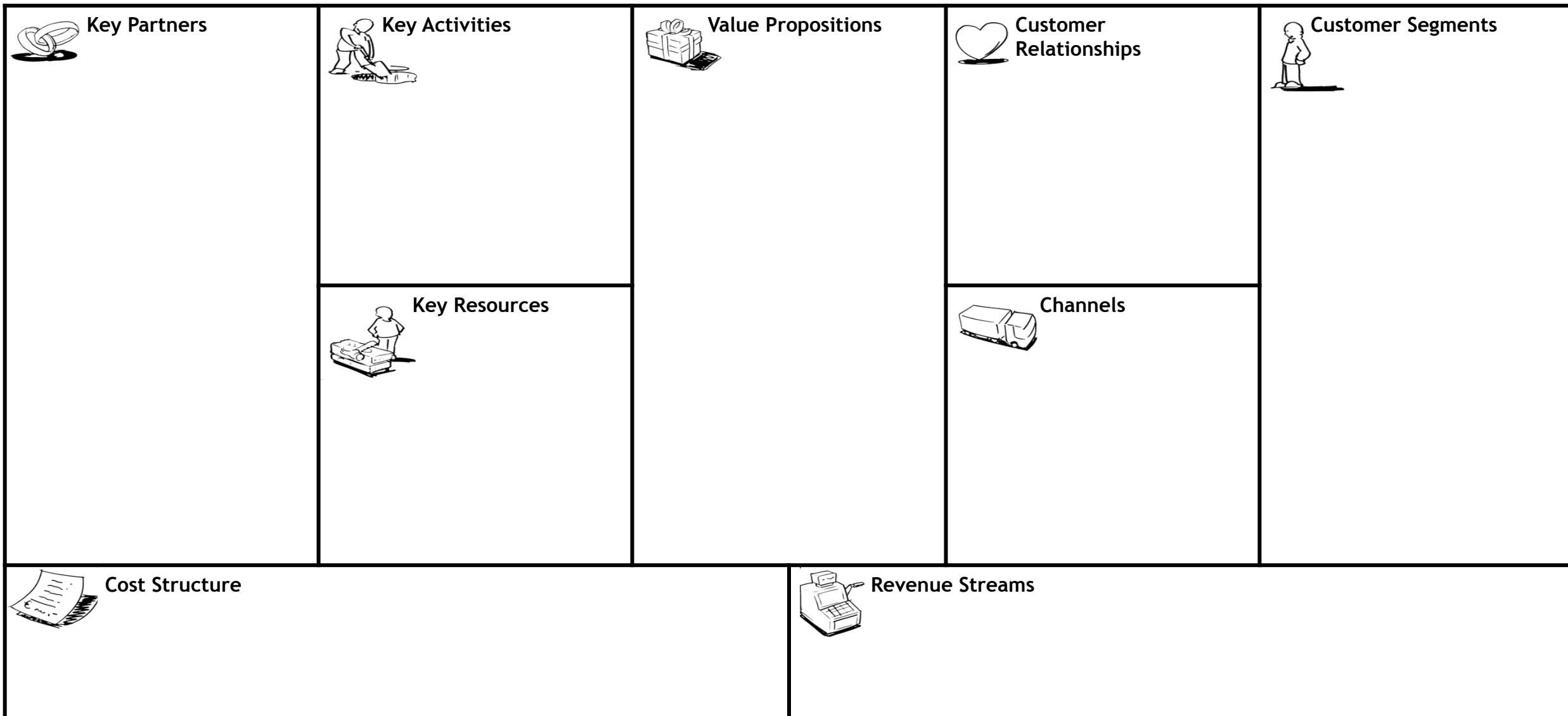
Source: Mullins, 2003

Step 2 Competition Analysis

Conduct continuous update about competition (existing or emerging alternative solutions)



Step 3 Business model generation



Step 4

Challenges and Risks

- Identification and assessment of the risks and barriers to be overcome in order to enable the exploitation of the results
- Characterize the root causes of risks that have been identified and quantified in
- Evaluate risk interactions and common causes.
- Identify alternative mitigation strategies, methods, and tools for each major risk.
- Assess and prioritize mitigation alternatives.
- Select and commit the resources required for specific risk mitigation alternatives.

Expected exploitable result	Likely risk	Mitigation / elimination strategy

Step 6

IPR Management

- Partners' individual exploitation interests
- Exploitation Team
- Entrepreneurial capacity
- Intellectual Property Rights (IPR) Analysis
 - Overview of IPR Agreements
 - Patents (existing or not)

IPR Ownership Matrix

Product	License	IP owner
Product X		
Product Y		
Service X		
Service Y		
Tool X		



Checklist for Exploitation

- ✓ Different **types of exploitable results** (knowledge, methods, agreements, networks, technologies) are clearly identified and their direct and indirect value and impact for different stakeholders are considered
- ✓ Describes the **exploitation plan** (market and industry analysis, competition analysis, business model) to ensure that the results meet real needs, and will be taken up by potential users
- ✓ Describes the **roles and responsibilities of partners** in exploiting results or supporting results exploitation by other (intermediate or end users)
- ✓ The **barriers and risks for exploitation** (actual use of the results after project funding) are recognized and countered with appropriate measures
- ✓ **IPR management activities** must be reported (ownership scheme patent applications, licenses, copyrighted/copylefted material, registered designs etc.)

Next Steps and Critical issues to discuss

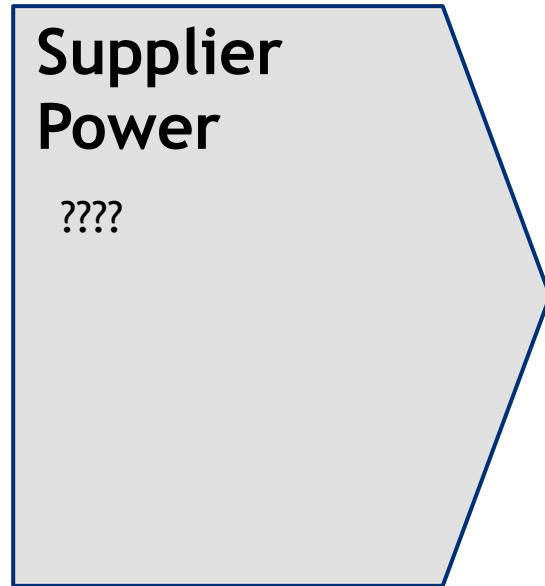
Step	Critical issue	Contributors
Collecting input regarding exploitable results from WP1-6	When? How?	Volunteers??
Share the methods and tools for exploitation (Value map, business model canvas, five domain model etc.) and decide on which of them to adopt	Share also educational material for each method	
Organize internal workshops (interviews or focus group) for identifying exploitable results, strategy and stakeholders (maybe in conjunction with the dissemination activities i.e. conference)	Build commitment	“
Design the quantitative online survey		“
Share and complete the quantitative online survey	Build commitment	
Develop the exploitation plan for each project result (market and industry analysis, SWOT analysis, competition analysis, business model) and the Productive 4 cross domain platform as a totality	Have a common approach, For each WP objective (1-6) assign a responsible partner	“
Identify and assess challenges and risks		“
Develop an IPR management	Situations of co-ownership	“



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Initial Market Research

Porter's 5 forces Analysis



Threat of New Entries

- Requires extended research to enter
- High barriers to entry
- Small number of potential new entrants
- High Cost ✓

Competitive Rivalry

- High Switching Cost
- High cost of leaving the market
- High customer loyalty
- Some competitors ✓



- Unique offering ✓
- Difficult to replicate
- Some Substitutes

Threat of Substitution



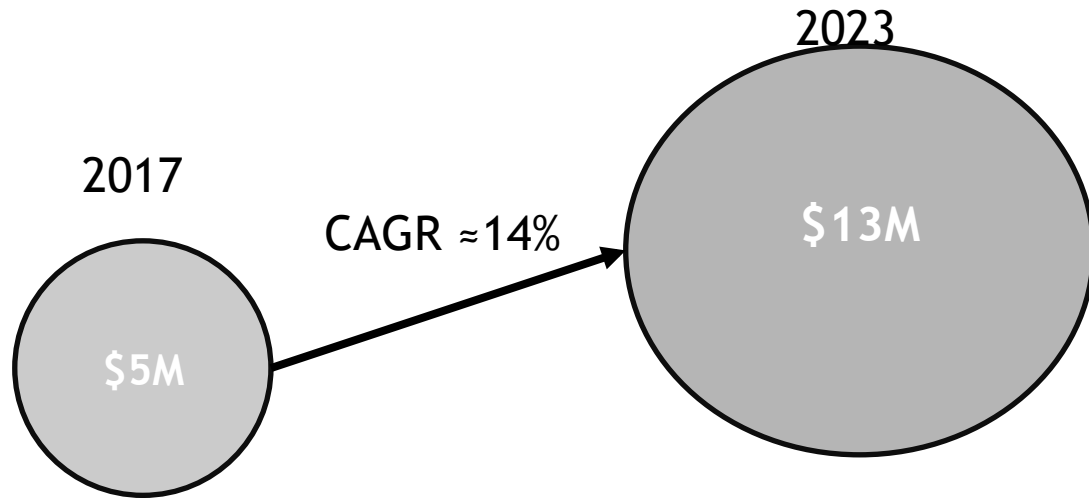
X-FEL derivative technologies can be applied in various promising sectors

- Medical
- Polymers
- Defense/Military
- Semiconductor Lithography
- Chemistry
- Advanced materials
- Biology
- Super-resolution Microscopy
- Metallurgy
- Agriculture

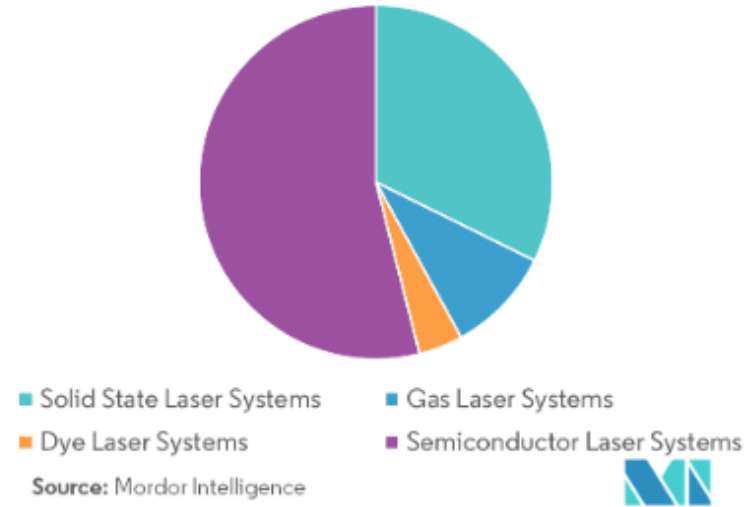


We picked several sectors to showcase the promising commercial value of the developed technologies

Market Size



Medical Laser Market: Revenue Share (%), By Product Type, Global, 2018



Characteristics

- Highly fragmented market
- Large growth globally
- North America is the largest market

Sub-sectors

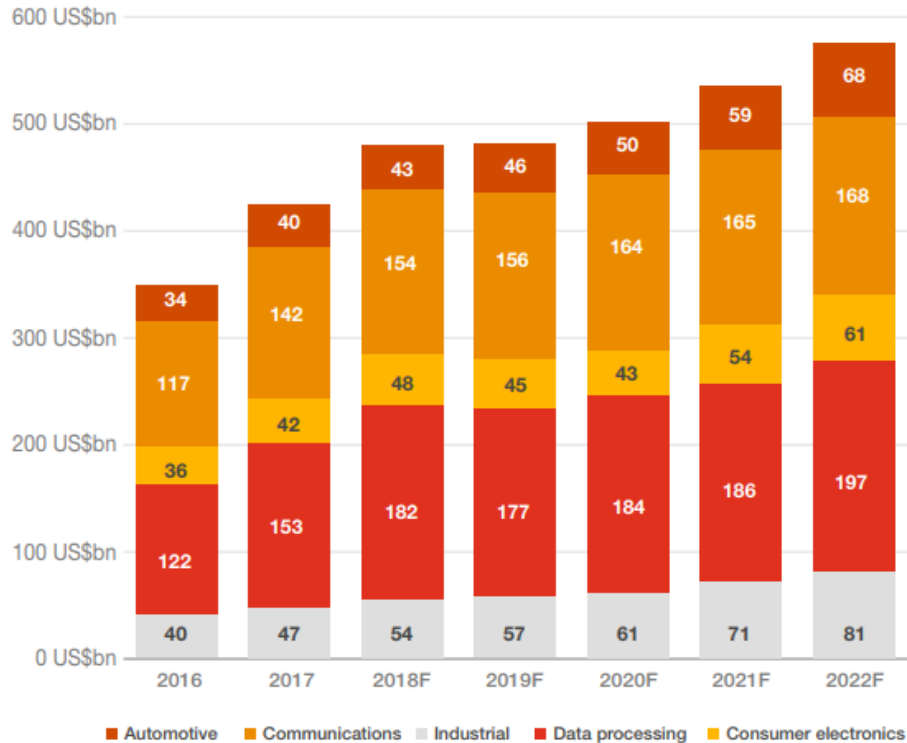
- Ophthalmology
- Dermatology
- Gynecology
- Dentistry
- Urology
- Cardiovascular

A highly promising area is the Semiconductor Lithography market

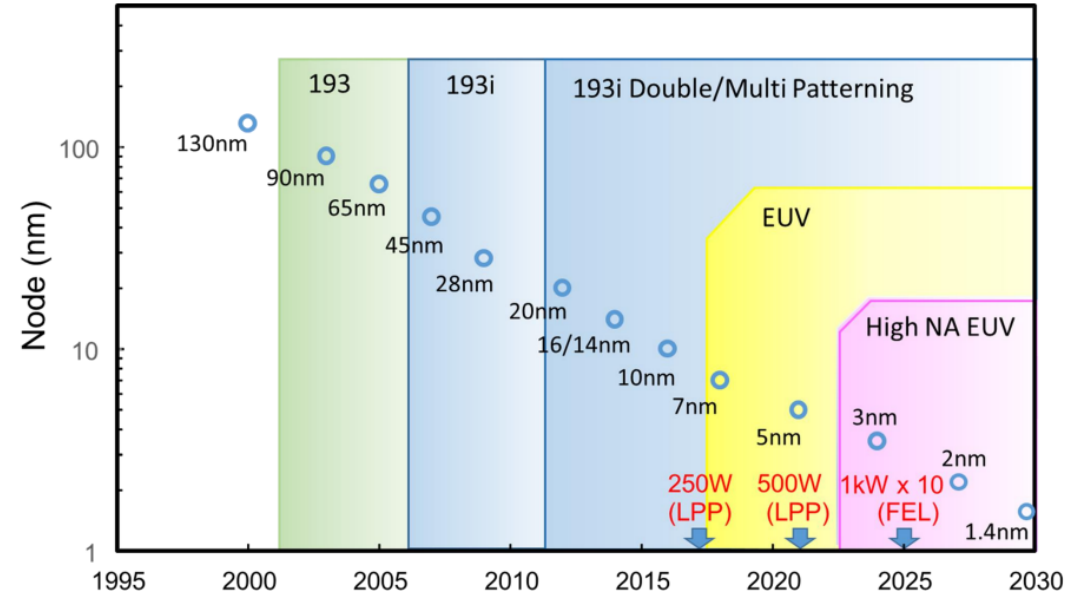
EUV-FEL Light source will be needed from the stage of 3nm Node (~2025).

It is important to develop the feasible technologies on ERL-FEL and also handling of the high peak power FEL light source.

Market Size and sub-sectors



Source: PwC research



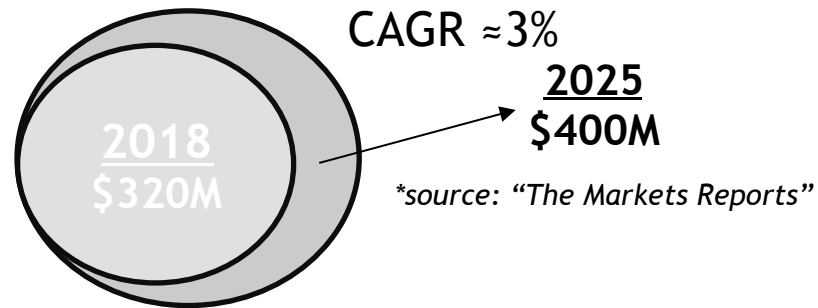
*source: Kawata H., 2017 Int. Workshop on EUV Lithography

Characteristics

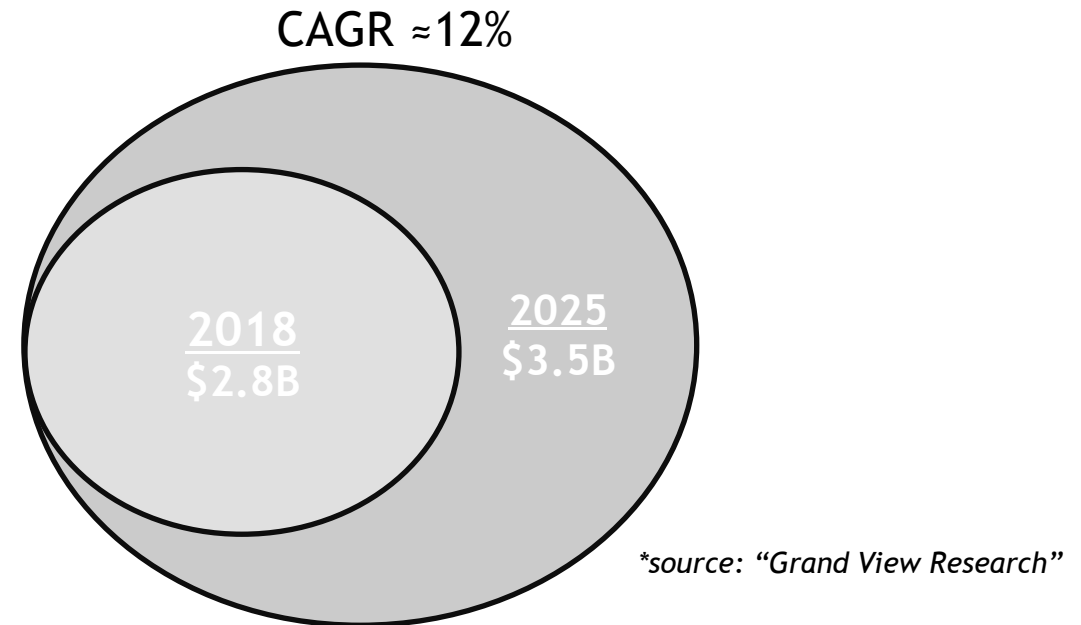
- Growing market
- Relatively saturated but rapidly evolving due to new technologies
- FEL technologies can provide lasting competitive advantage

There also other large and growing markets where X-FEL technologies can be applied

Isotope Separation



Super-resolution Microscopes



Improving on current knowledge in these sectors using FEL can drastically alter the current markets and provide new and improved products and services



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Cost Model Analysis



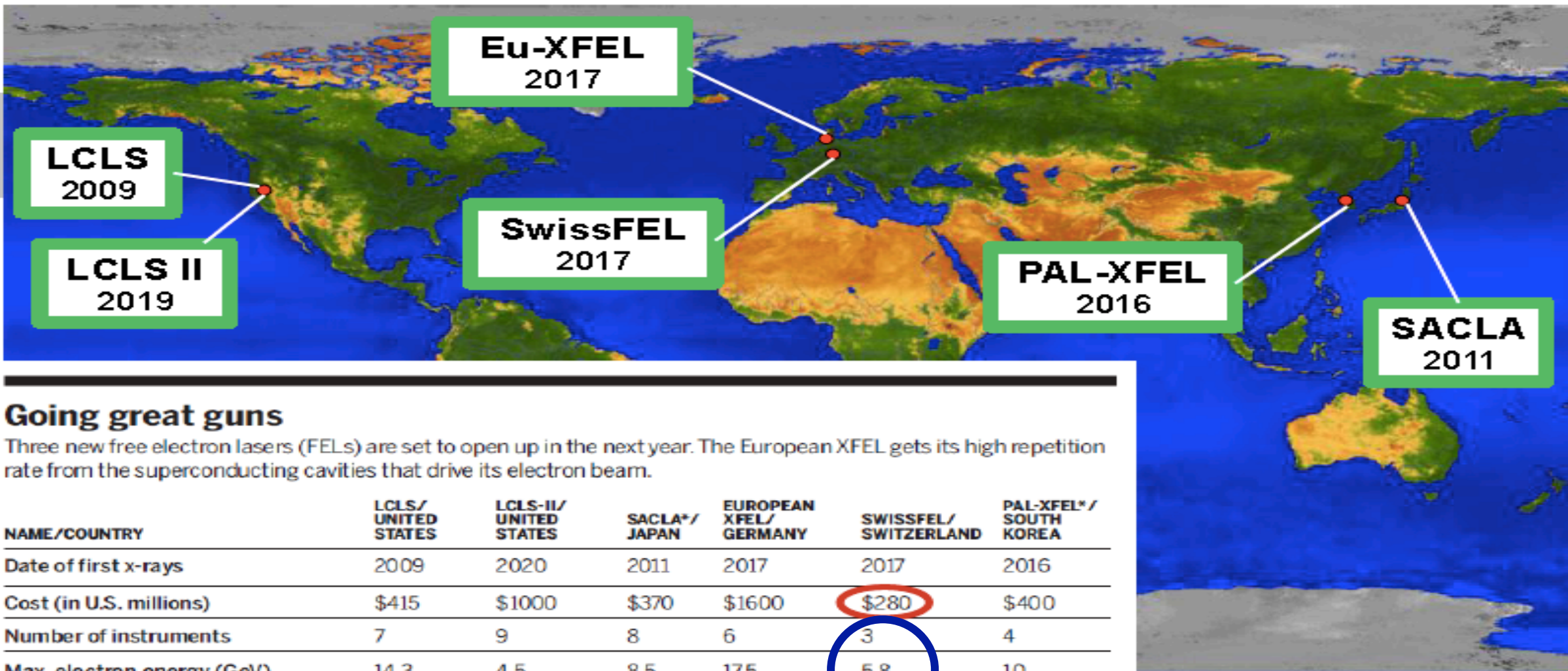
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COST of LCLS/EU/SWISS/SACLA/PAL -XFEL systems

by H.H. Braun (ATS Seminar, CERN, 22 June 2017)



X-FELs worldwide



Going great guns

Three new free electron lasers (FELs) are set to open up in the next year. The European XFEL gets its high repetition rate from the superconducting cavities that drive its electron beam.

NAME/COUNTRY	LCLS/ UNITED STATES	LCLS-II/ UNITED STATES	SACLA*/ JAPAN	EUROPEAN XFEL/ GERMANY	SWISSFEL/ SWITZERLAND	PAL-XFEL* / SOUTH KOREA
Date of first x-rays	2009	2020	2011	2017	2017	2016
Cost (in U.S. millions)	\$415	\$1000	\$370	\$1600	\$280	\$400
Number of instruments	7	9	8	6	3	4
Max. electron energy (GeV)	14.3	4.5	8.5	17.5	5.8	10
Min. pulse duration (femtoseconds)	15	15	10	5	2	30
Pulses per second	120	1,000,000	60	27,000	100	60

*SACLA is the Spring-8 Anestrom Compact free electron Laser and PAL-XFEL is the Pohang Accelerator Laboratory X-ray Free Electron Laser



■ Sub-Systems

- RF-Gun
- Injector
- Main Linac
- Klystrons
- Bunch Compressors
- Magnets
- Undulator System
- Controls & Operation

Rough %

6
9
16
25
10
5
25
4



Sub-Systems

- RF-Gun
- Injector linac
- Main linacs
- Klystrons
- Bunch Compressors
- Main Dump System
- Undulators
- Infrastructure & Services
- Machine Control, Protection & Operation

Rough %

- 6
- 9
- 23
- 20
- 10
- 6
- 15
- 4
- 4

Final %

Values are expected from the Carlo Rossi table breakdown structure of parts

A QUESTIONNAIRE is under preparation for WP leaders



■ Questionnaire (draft)

- Main devices
- Raw Materials
- Labor cost
- Licenses
- Software
- Capital investment cost vs business plan time
- Others
- Machine Commissioning & Operation
- Machine Maintenance

1. RF Gun System

RF Gun System				
	Level 1	Level 2	Level 3	Level 4
CODE	Name*	Name*	Name*	Name*
ROOT	XLS			
1	RF Gun System			
1.1		Photocathode System		
1.2		Laser System		
1.3		RF System		
1.3.1			Klystron Modulator System	
1.3.1.1				Modulator
1.3.1.2				Klystron
1.3.1.3				Solenoid System
1.3.2			RF Power Distribution System	
1.3.2.1				RF Waveguide System
1.3.2.2				RF Loads and Hybrids
1.3.3			RF Gun Cavity	
1.3.4			Low Level RF & Timing	
1.3.4.1				RF Driver Amplifiers
1.3.4.2				RF Signal Acquisition and Control
1.3.4.3				Timing Generation and Distribution
1.4		Support and Alignment System		
1.4.1			Alignment DAQ and Control System	
1.4.2			Alignment Instrumentation System	
1.5		RF Gun Vacuum System		
1.5.1			Vacuum Pumps and Connecting Elements	
1.5.2			Vacuum Power Supply	
1.5.3			Vacuum Instrumentation System	

1. RF Gun System, continued

1.6	Magnets and Correctors		
1.6.1		Beam Focusing	
1.6.1.1			Solenoid Magnet
1.6.1.2			Solenoid Power Supply
1.6.1.3			Hall probe
1.7	Beam Instrumentation System		
1.7.1	Electron Beam Daignostics		
1.7.1.1		Beam Current Transformer	
1.7.1.2		Beam Position Monitor	
1.7.1.3		Transverse Profile Monitor	OTR/YAG:Ce-type crystalscreen monitor
1.7.1.4		Longitudinal Profile Monitor	
1.7.1.5		Emittance Monitor	
1.7.1.6		Beam Loss Monitor	
1.7.1.7		Transverse Deflecting Cavities	High-resolution bunch length
1.7.2	Photon Beam Diagnostics		
1.7.2.1		Photon Intensity	
1.7.2.2		Photon Beam Posistion	
1.7.2.2		Pulse Length & Time Arrival	THz camera
1.7.2.3		Photon Wavelength	Bragg crystal
1.7.2.4		Attenuation (Gas+Solid)	Gas attenuation
1.7.2.5		In-beam Detectors	Screens
1.8	RF Gun Interface to Infrastructure		
1.8.1		Cavity Tuning Control Interface	Cavity Temperature Control
1.8.2		Control System Interface	Control System
1.8.3		High-speed Communication Link	Diagnostics System
1.9	RF Gun Commissioning		



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Thank you!



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