CISB | CENTRO DE PESQUISA E INOVAÇÃO SUECO-BRASILEIRO

4th Annual Meeting

Future Vision in Composites & Manufacturing and their Challenges

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Agenda

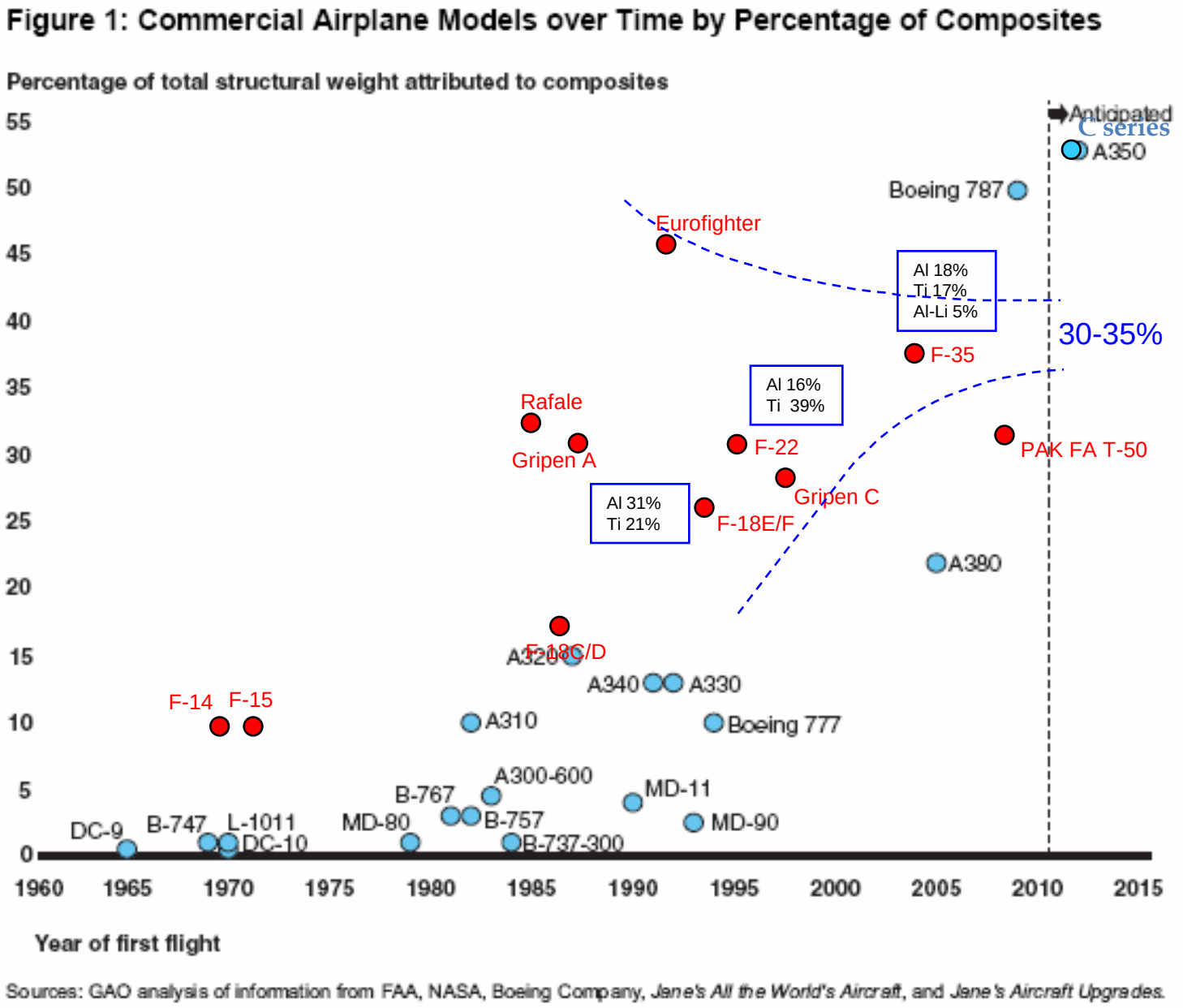
- Introduction , Composites & Manufacturing
- Trends
  - general
  - aeronautics, civil and military
- Examples of Swedish activities
  - Industry
  - National Strategic Innovation Programmes
  - LIGHTer, Graphene, Production, Innovair

55 Years of Progress?

1954
Boeing 707
Chevrolet Corvette

2009
Boeing 787
Chevrolet Corvette

TRENDS IN STRUCTURAL MATERIALS



Sources: GAO analysis of information from FAA, NASA, Boeing Company, *Jane's All the World's Aircraft*, and *Jane's Aircraft Upgrades*.

TECHNOLOGY - DESIGN DRIVERS AND ENABLERS






Faster & Safer | Efficient | Green

Composites | 10% | 25% | 50% | Next x-generation advanced composite

- Product Families
- Low drag-wings
- De-moisturizing
- Natural laminar flow
- Open Rotor Engine
- Optimal configurations
- non circular fuselage structure
- Integrated engine in airframe
- Active laminar flow
- All Electric aircraft
- More Electric Aircraft (energy optim.)
- Nanotechn, multifunctional structure
- Automatic production of composites
- More efficient production
- Alternative fuel
- Prognostics/diagnostics, maint. opt.
- Pilot-support – increased autonomy
- Model based development
- Demonstrators
- Improved aero efficiency
- Fuel Cells
- Autonomous Transport (UAV)
- Functional, self-healing materials
- Integrated Structure/system
- Adaptive wings optimized for flight condition

Basic Aeronautics

- FBW - Fly by wire
- TCAS - Traffic Collision Avoidance Systems
- EFIS - Electronic Flight Instrumentation System
- IMA - Integrated Modular Avionics
- Digital Computers
- Multimode radar
- Advanced, passive electrooptic sensors
- 2nd generation Radar- & IR-missiles
- Data link
- Miniaturization
- Engine: Increased thrust-to-weight
- Stealth, 2nd generation
- Conformal Stealth apertures
- Network connection
- Broadband data link, long range
- AESA-radar
- Multispectral sensors
- Advanced Electronic Warfare
- Autonomy, Decision suppport
- Precision weapon, graded effect
- "Counter-Stealth"
- UCAV – unmanned combat
- Plasma (Stealth & flow control)
- "Stand-off" smart strike weapon
- Stealth, 1st generation

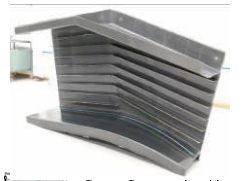
Speed | Complex system | Energy, Light weight | Multi-role | Stealth | Availability & Cost

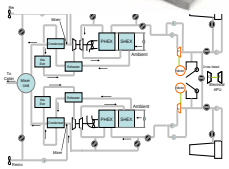




1970 | 1980 | 1990 | 2000 | 2010 | 2020 | 2030

Technology Readiness Level (TRL)





TRL9 Product in use

TRL8 Product Development

TRL7 System demo in actual environment

TRL6 Demo sub system level

TRL5

TRL4 Applied Research, lab verification

TRL3

TRL2 Basic Research

TRL1

R&T

R&D

FUTURE SYSTEM OF MILITARY AIRCRAFT

Unmanned systems

ISR

Manned and Unmanned Future Combat Air Systems

E F E+ …

Gripen

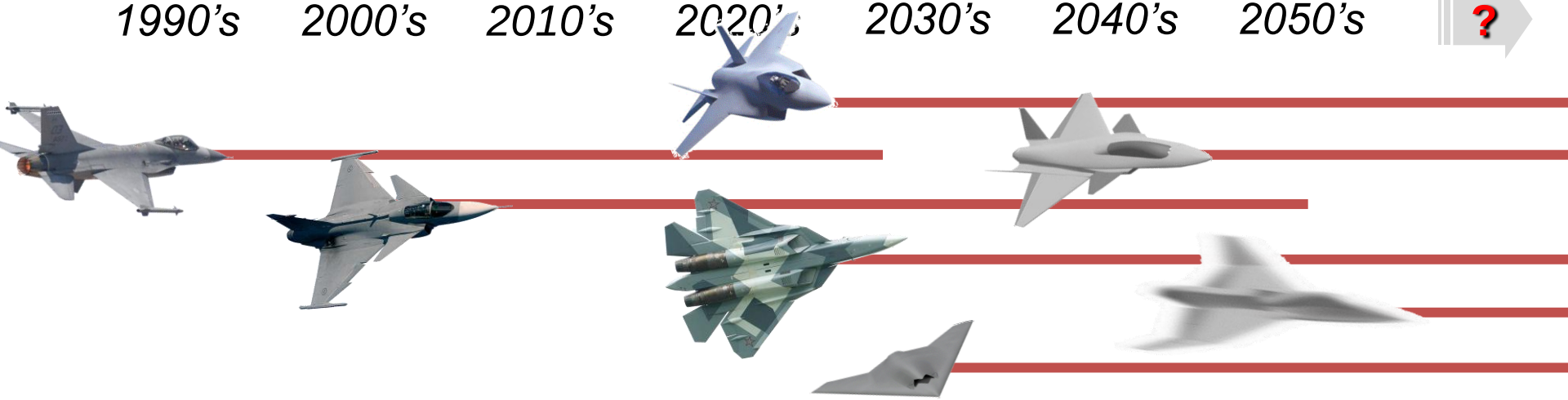
2015 2040 2060

GENERAL TRENDS IN INDUSTRY 2015-2030

- **Autonomous and Intelligent Systems**
  - Mixed initiative Man & Machine
- **Sensors and Sensor Networks**
  - Sensors integrated in the strucutre
- **Materials Technology**
  - Material design at micro/nano/atom levels
- **New energy sources and energy storage**
  - Challenges to produce and operate in large numbers
- **Next generation computing**
  - ”Unlimited simulation capability”

TECHNOLOGY TRENDS & DESIGN DRIVERS

1990's 2000's 2010's 2020's 2030's 2040's 2050's ?



Stealth ISR UAS VLO UAS

Stealth detection (Low freq & EO)

Network Enabled

Energy weapons (HPM, Laser)

Multirole

Functional (Nano) materials

TVC - Thrust Vectoring

SEP & Maneuverability

Extended Autonomy & Decision Support

Autonomous, Seamless Collaboration

Plasma flow control?

Stand-Off strike

Enhanced sensors & datafusion

Environmental focus

Variable Cycle Engines

Lightweight Fighters

Availability & Affordability

Civil / Dual technology

Extended Range/Endurance

Miniaturization

Morphing geometry?

Cyber Threats

Smaller weapons tailored for IWB

Quantum computers?

….. Avionics - Architectures, computers, databuses, software – several new generations in shorter cycles …..

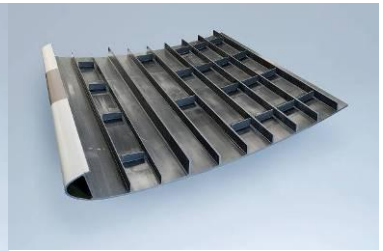
Future Composites (Near Term)

- Reduce cost and weight
  - High rate production processes, automation in assembly
  - More integral structure
- Environmentally friendly
  - Biomaterials
- Multifunctional materials, tailored properties
  - integrated antennaes
  - materials transparent to some frequencies
  - nanotechnology
  - batteries integrated in the structure
- New applications in a production environment
  - composites in tooling and fixtures
- Increased design freedom
  - Hybrid structures, metal+composites
  - 3D weaving
  - Mimic nature in design
  - Composites in aircraft engines
- Monitoring of properties during the service life
- Need for research and education

Future Manufacturing (Near Term)

- Reduce cost
  - automation in assembly
  - tolerances
  - increase material usage, recycling
- Reduce weight
  - Welding, new methods and applications
  - Titanium, new alloys
  - Increased use of composites
- Additive Manufacturing (reduce time)
  - knowledge, sizing data, fatigue properties
- Simulation capability at all levels of detail
- Need for research and education

HIGH PRECISION INTEGRAL STRUCTURES - EU CLEAN SKY 1 Laminar flow wing



Cooperation across industry sectors - Triple Use project

- Production technologies for high volume composites manufacturing
- Cooperation between
  - Civil aeronautics
  - Military aeronautics
  - Automotive
- Saab, GKN, Volvo Cars, Swerea, KTH

Strategic Innovation Programmes

All national stakeholders (industry, academia, government) agree on long term objectives and a roadmap to get there

With support from:

VINNOVA

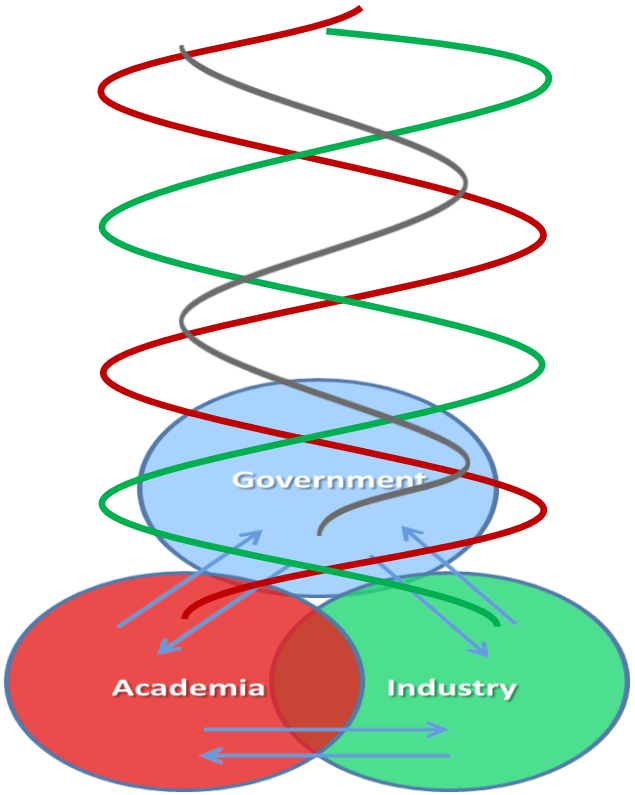
Swedish Energy Agency

formas

STRATEGIC INNOVATION AREAS

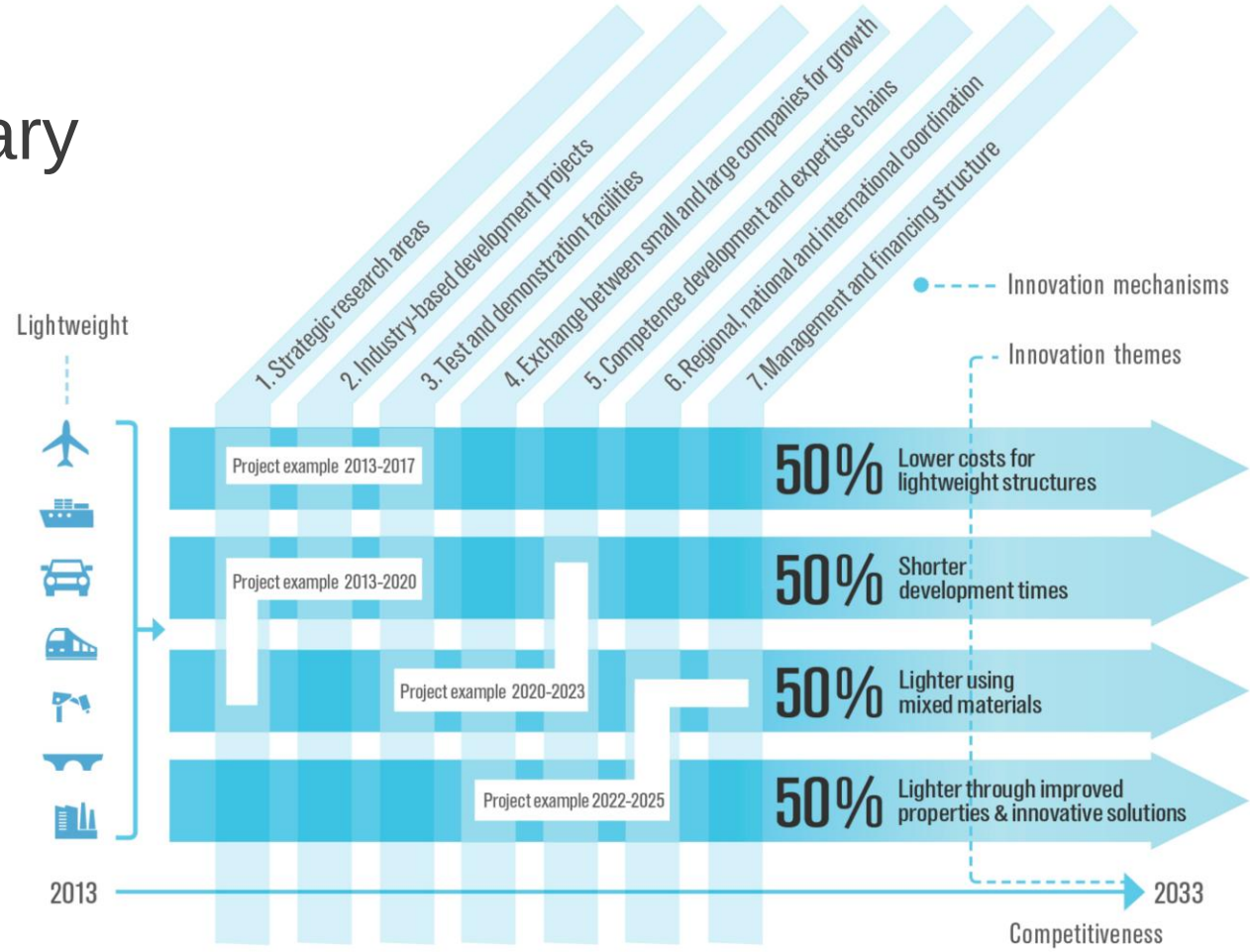
11 Strategic Innovation Programs in Sweden

(Saab participation in blue)

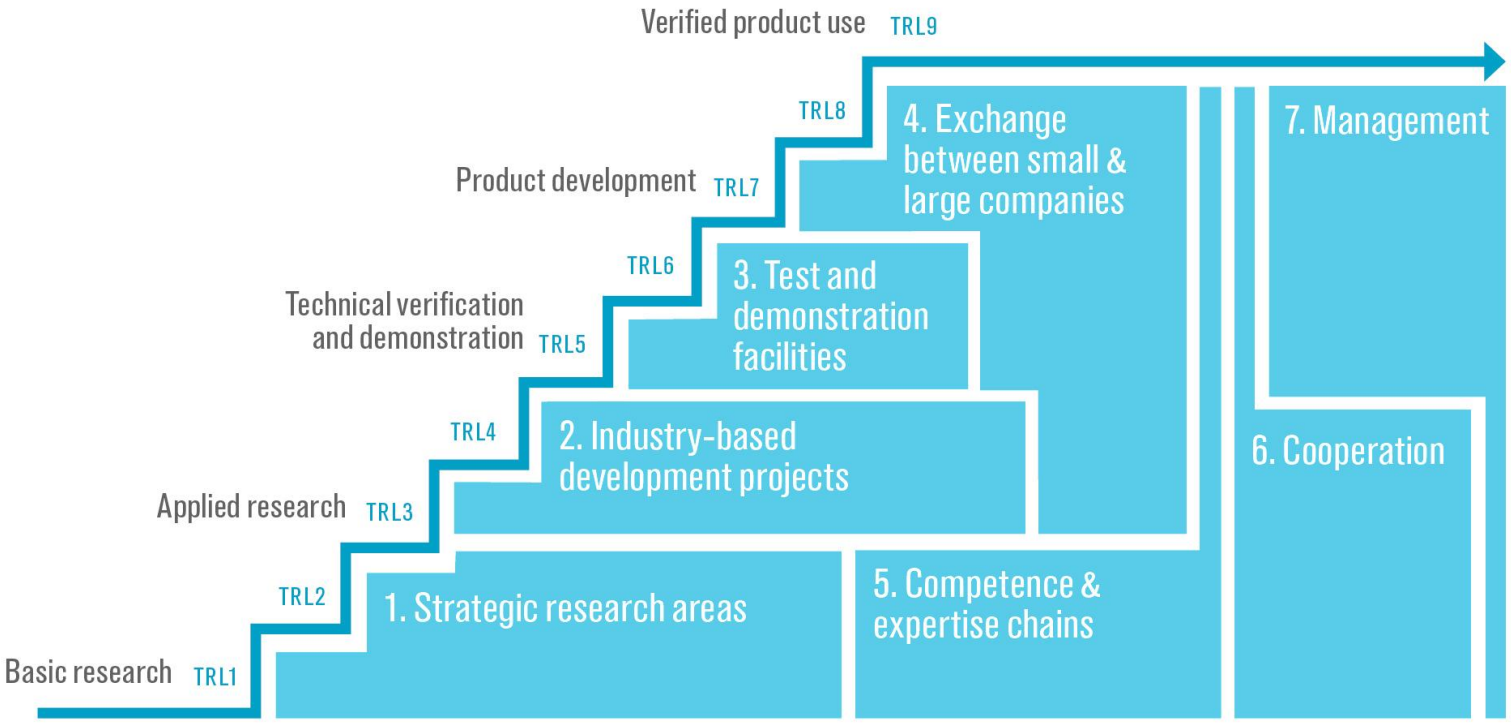


1. Aeronautics (Innovair)
2. Graphene
3. Electronic components and systems
4. Internet of things
5. Bio-based materials, products and services
6. Endemic diseases
7. Metallic materials
8. Light weight structures (LIGHTer)
9. Process Industrial IT and Automation
10. Production2030
11. Mining and metal extraction

Itinerary


1. Strategic research areas
2. Industry-based development projects
3. Test and demonstration facilities
4. Exchange between small and large companies for growth
5. Competence development and expertise chains
6. Regional, national and international coordination
7. Management and financing structure
Innovation mechanisms
Innovation themes
Lightweight
Project example 2013-2017
50% Lower costs for lightweight structures
Project example 2013-2020
50% Shorter development times
Project example 2020-2023
50% Lighter using mixed materials
Project example 2022-2025
50% Lighter through improved properties & innovative solutions
2013
2033
Competitiveness

Seven mechanisms for growth



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