

Seminar in Aeronautics

Brasília, May 16, 2016

LiU-UFSC-SAAB cooperation on efficient hydraulic systems for aeronautics

Prof. Victor J. De Negri
Federal University of Santa Catarina
Department of Mechanical Engineering
LASHIP - Laboratory of Hydraulic and Pneumatic Systems



- The Starting Point of Collaboration
- Industry-Academic Collaboration – Brazil
- Speeches about University-Industry Experiences
- Organization of Swedish-Brazilian Workshops
- Collaboration on Research Projects
- Ongoing Project: **Efficient Hydraulic Hybrid Systems for Aeronautical Applications**
- Next Steps

The Starting Point of Collaboration

- **February, 2011** – São B. do Campo, São Paulo
 - CISB - Brazilian-Swedish Research and Innovation Workshop II
 - Meeting between FEI – LiU – UFSC - UFABC
 Startup of joint activities between **Petter Krus** (LiU) and **Victor J. De Negri** (UFSC) **on the field of fluid power systems, design methodology, and aeronautic applications**



CISB - Centro de Pesquisa e Inovação Sueco-Brasileiro

Dates & Venue
 May 17 & 18, 2011

CISB - Centro de Pesquisa e Inovação Sueco-Brasileiro
 ACISBEC - Associação Comercial e Industrial de São Bernardo do Campo
 Rua do Imperador, 14, São Bernardo do Campo - São Paulo

Preliminary Agenda

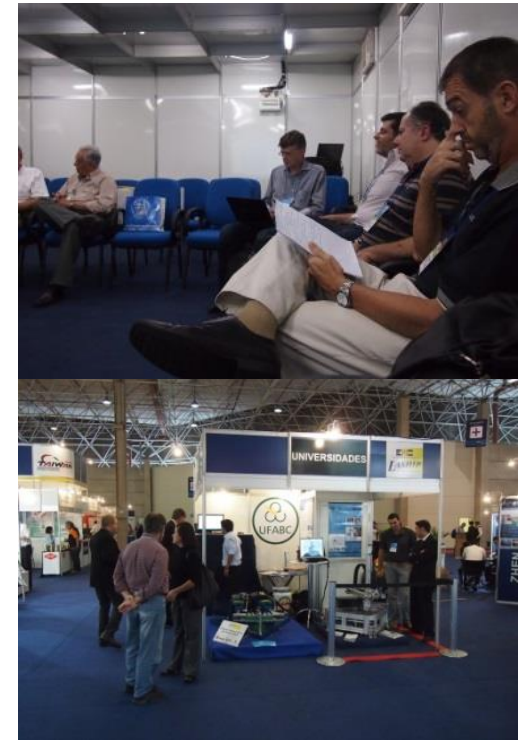
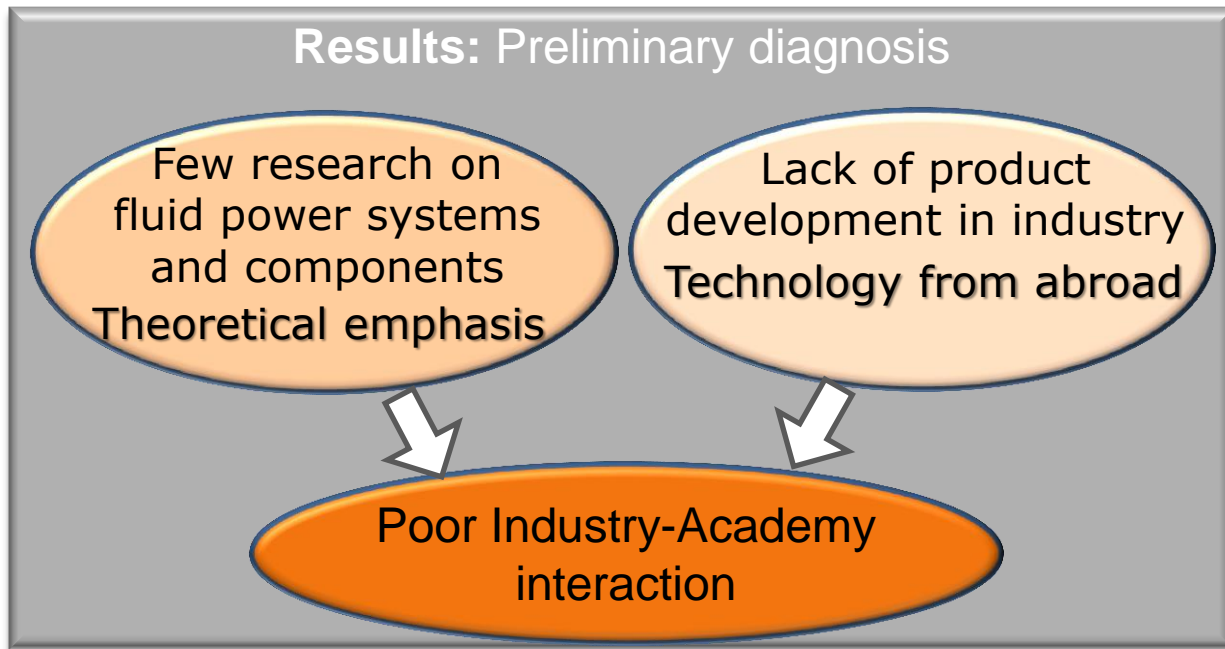
Tuesday, May 17th

- 10:00 Registration
- 10:30 Introduction to CISB: Strategy & Members
 Pontus de Laval, Chief Technology Officer, SAAB
- 10:45 Modus Operandi of CISB: Bylaws & Open Innovation Management
 Graciema A. de Almeida, Partner, Pinheiro Neto
 Bruno Rondani, Executive Director for the Implementation, CISB
- 11:30 Challenge Driven Innovation: Focus Areas for CISB
 Speaker indicated by VINNOVA and ABDI
- 12:00 Buffer Lunch
- 13:00 Challenge Overview: Transport & Logistics
 Dario Thobler, Centro de Pesquisas Avançadas Wernher von Braun
- 13:45 Challenge Overview: Defence & Security
 Tarciso Takachi Muta, President, Altech
- 14:30 Coffee Break
- 14:45 Challenge Overview: Sustainable Energy & Biorefineries
 Semida Silveira, Head of Division, Royal Institute of Technology
- 15:30 Challenge Overview: Urban Future & Innovation
 Paul Linnvall, Chairman of City Board, Linköping
- 16:15 Discussion & Conclusion
- 17:00 Closing notes

- **May, 2011** – São B. do Campo, São Paulo
 - Inauguration of the Swedish-Brazilian Research and Innovation Centre (CISB)

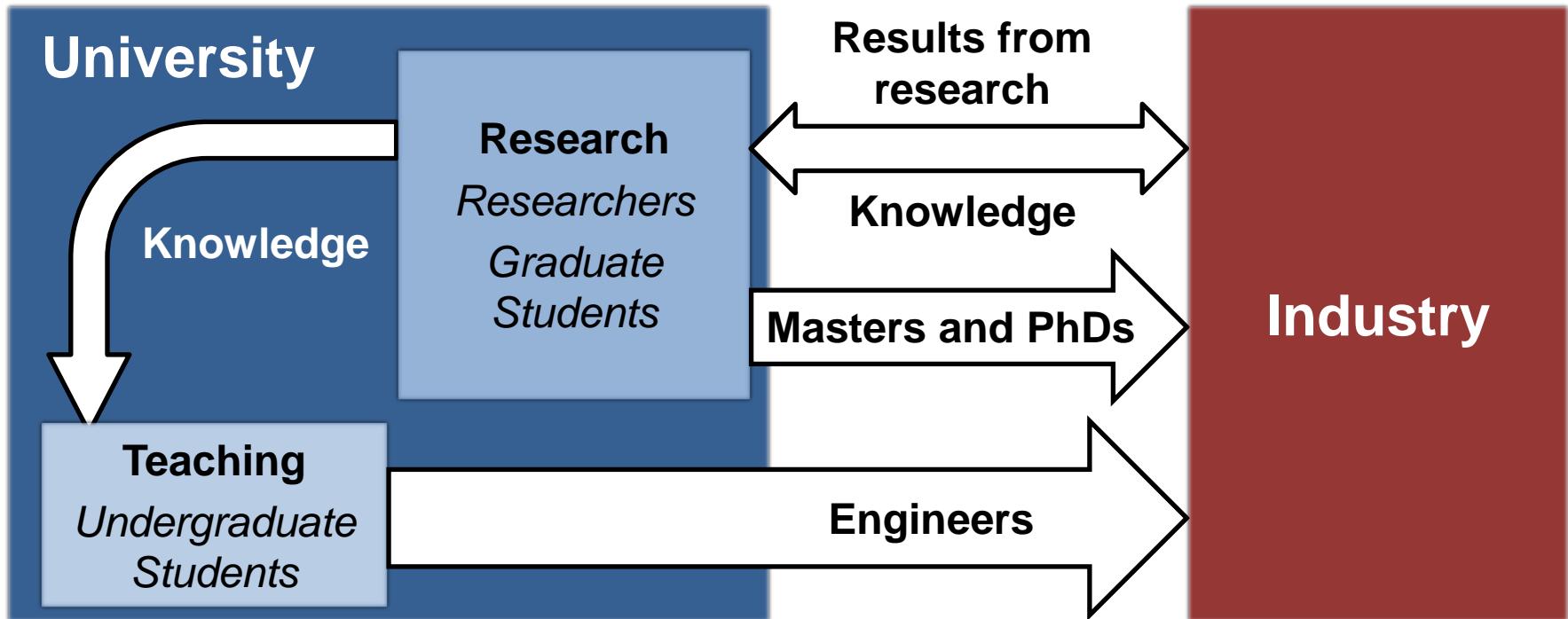
Industry-Academic Collaboration - Brazil

- **March, 2013** – São Paulo – Centro de Exposições Imigrantes
 - **Meeting Industry-Academy: Teaching and Research on H&P:**
 - **From industry:** Hydraulic Designers; AT Automação; Moog; RKM; Schulz; Airzap; Bosch Rexroth; TCT-Treinamento; ABIMAQ
 - **From academy:** UFABC (Prof. Luciana Pereira); FEI (Prof. Agenor Fleury); Linköping University; UFSC



Industry-Academic Collaboration - Brazil

- **ABIMAQ/CSHPA (Chamber of Hydraulics, Pneumatics, and Automation Systems)**
 - Discussion about:
 - Actions for Teaching, Research and Innovation
 - Opportunities for R&D funding in industry



Speeches about University-Industry Experiences

▪ COBEM 2013 - International Conference on Mechanical Engineering

• Special session Organized by LASHIP/UFSC & Sponsored by ABIMAQ

- Ribeirão Preto, SP
- Invited speaker: Prof. Petter Krus
- + 2 participants from FLUMES/LiU



- **Hydraulikdaggar 2012, 2015**
- **MODPROD 2016**
 - Organized by FLUMES/LiU
 - Linköping, SE
 - Invited speaker: Prof. Victor De Negri

Special Sessions on Hydraulics and Pneumatics			
5 TUESDAY	ROOM 8	Chair: Victor Juliano De Negri Co-chair: Luciana Pereira	ORAL SESSION
8:00	8:20	Component sizing study for a light-duty series hydraulic hybrid vehicle in urban drive cycles.	Katharina Baer Linköping University - Sweden
8:20	8:40	Hydraulics technology for machineries according to NR12 - Brazilian standard for machineries safety.	Rodrigo Rodrigues Makoto Yokoyama Bosch Rexroth - Brazil
8:40	9:00	Actuation and supervision wireless of pneumatic actuator trough ZigBee protocol and Arduino.	Adauto Granja Paulista University / UNIP - Brazil
9:00	9:20	Use of surface electromyography to control an active upper limb exoskeleton actuated by pneumatic artificial muscles and optimized with genetic algorithms.	João L. A. Souza Ramos Pontifical Catholic University of Rio de Janeiro / PUC-RIO - Brazil
9:20	9:40	Field bus and pneumatic systems for industrial automation	Fábio Rosa de Oliveira Camozi do Brasil - Brazil
9:40	10:00	Development of a fatigue testing machine using a pneumatic artificial muscle.	Juan G. Castillo Alva Pontifical Catholic University of Rio de Janeiro / PUC-RIO - Brazil

Hydraulikdaggar 2012 - Innovation och globalisering

Sweden, April 17 – 18, 2012

FLUID POWER IN BRAZIL: Market, Opportunities, and Research

Victor Juliano De Negri, D. Eng.
 Associate Professor at Federal University of Santa Catarina
 Head of Department of Mechanical Engineering
 Coordinator of LASHIP - Laboratory of Hydraulic and Pneumatic Systems



▪ **Workshops organized by UFABC:**

- **Chairperson: Prof. Luciana Pereira**
- **Speakers: Prof. Petter Krus, Prof. Victor De Negri**
- **May, 2014 - Workshop - Technological Innovation Challenges: Building Bridges Between Academy and Industry**
- **November, 2014 - Workshop on Design and Product Development for Innovation: connecting people, disciplines, and ideas.**
- **November 2015 - Workshop Systems, Product Development and Innovation**



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Workshop - Systems, Product Development and Innovation

Undergraduate, Master's and Doctorate Students Involved on Academic and Industrial Projects

Federal University of Santa Catarina
Technological Centre
Mechanical Engineering Department
Laboratory of Hydraulic and Pneumatic Systems

Prof. Victor Juliano De Negri
Santo André, November 13, 2015

Research Collaboration for Future Capabilities

Petter Krus
Swedish Aeronautics Chair at ITA/
Fluid and Mechatronic Systems
Department of Management and Engineering
Linköping University



Organization of Swedish-Brazilian Workshops

Workshop on Strategic Actions for Engineering Teaching and Research

- November, 2015, UFSC, Florianópolis
- Visit to Sapiens Parque and FIESC



14 speakers from:



A Swedish - Brazilian Initiative

Workshop on Strategic Actions for Engineering Teaching and Research

November 16 - 17, 2015

Federal University of Santa Catarina, Florianópolis, SC, Brazil

Auditorium of the Department of Mechanical Engineering (Building A)

Organized by Department of Mechanical Engineering of Federal University Santa Catarina (EMC/UFSC) and Department of Management and Engineering of Linköping University (IEI/LiU)

Organizing committee:

Prof. Victor J. De Negri

Prof. Acires Dias

Prof. Petter Krus



Organization of Swedish-Brazilian Workshops

Workshop on Innovative Engineering for Fluid Power

- 1st WIEFP, 2012, ABIMAQ Headquarters, São Paulo
- 21 Speakers, 8 from Europe and USA
- 52 participants



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Swedish-Brazilian Workshop on Innovative Engineering for Fluid Power and Vehicular Systems
 May 14-15, 2012, São Paulo, SP, Brazil

Organization and Sponsoring

CISB CENTRO DE PESQUISA E DESENVOLVIMENTO EM SISTEMAS DE VEÍCULOS
 ABIMAQ ASSOCIAÇÃO BRASILEIRA DE INDUSTRIA DE VEICULOS AUTOMOTORES

Organization

UNIVERSIDADE FEDERAL DE SANTA CATARINA
 Linköping University
 UFABC
 ABIMAQ

Sponsoring

SAAB

The purpose of this workshop is to bring together industry and academia, from both Brazil and Sweden, interested in this rapidly evolving multidisciplinary field of fluid power, drives, actuation and control systems for vehicles.

WIEFP 2014

2nd Workshop on Innovative Engineering for Fluid Power: Applications in Aircraft, Vehicles, and Energy

September 2 - 3, 2014
 FLOOR 3rd
 ABIMAQ Convention Center
 São Paulo, SP - Brazil

Organization

UFSC Linköping University UFABC CISB
 LASHiP FluMeS iLab@UFABC ABIMAQ

Sponsoring

ABIMAQ SAAB REIVAX

- 2nd WIEFP, 2014, ABIMAQ Headquarters, São Paulo
- 22 Speakers, 5 from Europe and USA
- 55 participants





iLab@UFABC

Next WIEFP: October, 2016, Florianópolis, SC, Brazil

3rd WIEFP:

- Organized by:



- 24-25 October
- Invited speakers from industry and academy
- Audience: Industry and academy professionals; Undergrad. and grad. students



9th FPNI Ph.D. Symposium

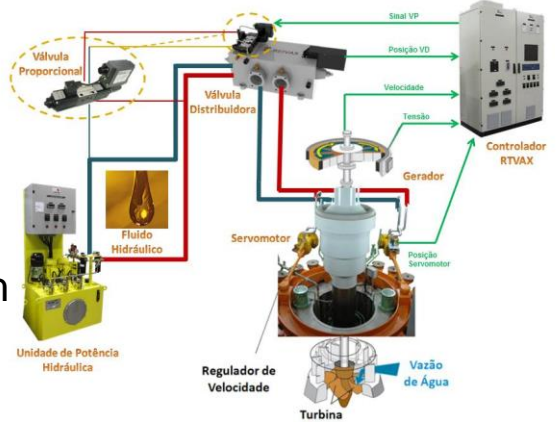
- Organized by:



- 26-28 October
- Invited speakers from industry and academy
- Paper presentations by Master's and Ph.D. students
- Audience: Graduate students, researchers, and professors

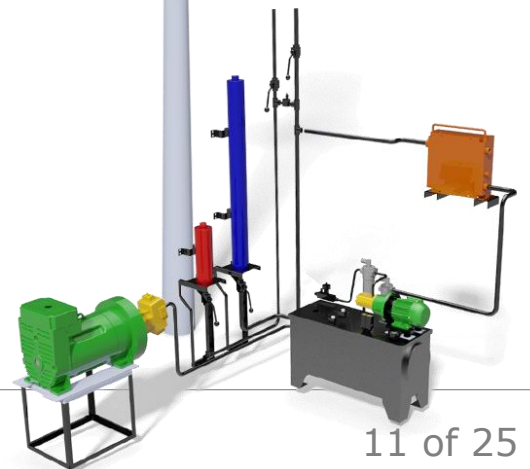


- Research Projects:
 - Speed governor based on condition monitoring for early fault detection



- Prof. Petter Krus: 2 weeks in Brazil
- Ph.D. Student Robert Braun: 1 month

- Hydrostatic Transmission for Rotor-Generator Coupling
 - Brazilian Master's Students: Eduardo Flesch & Henrique Randuez
 - Swedish Master's Students: Jonatan Turesson & Joel Rapp



Efficient Hydraulic Hybrid Systems for Aeronautical Applications



- Science Without Borders Program
- CISB calls

• Cooperation between Brazilian and Swedish researchers

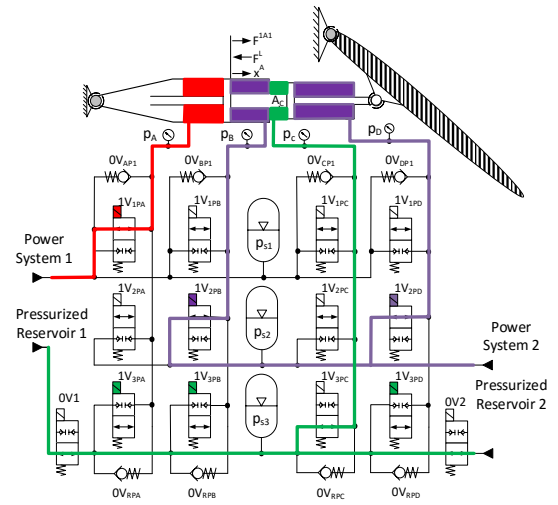
- Professor Petter Krus, Linköping University
- Professor Victor De Negri, Federal University of Santa Catarina
- Dr.^a Birgitta Lantto, SAAB AB

• Ph.D. Students:

- Cristiano Cardoso Locateli
- Henri Carlo Belan

• PostDoc:

- Lie Pablo Grala Pinto





- Development of innovative hydraulic systems with increased energy efficiency for aircraft onboard systems
 - Focus on flight control actuation:
 - Actuation systems
 - Hydraulic power unit
 - Impact on the aircraft hydraulic architecture

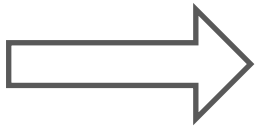
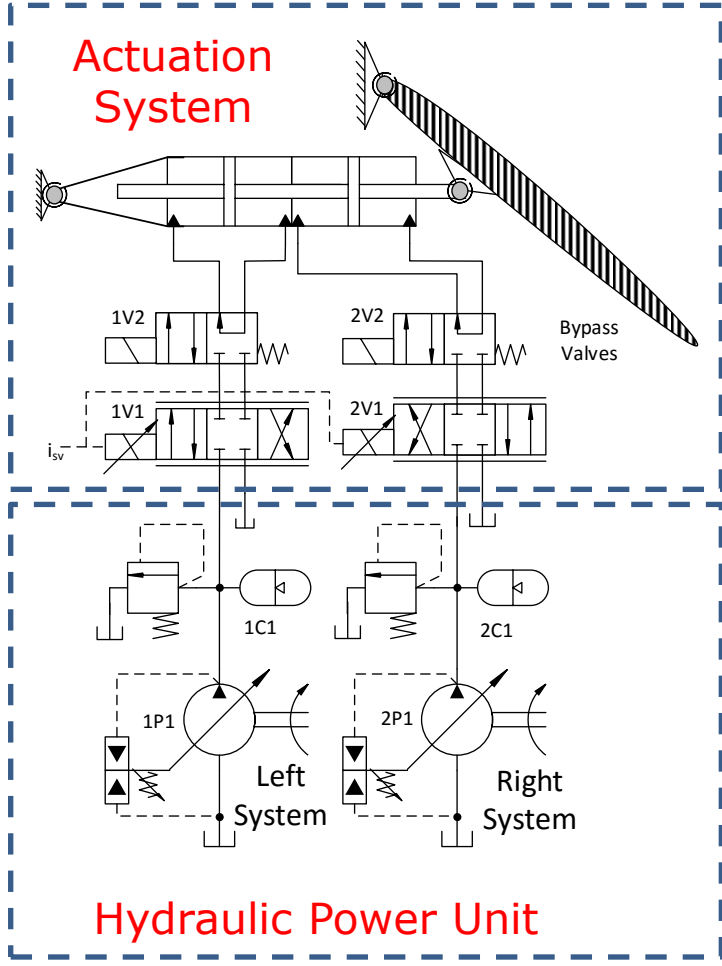


- Energy losses
 - Equipment with higher efficiency may lower its own weight
 - Energy losses often increase total aircraft weight/fuel consumption. Increase of:
 - Cooling system and piping
 - Ram air channels and drag
 - Remaining (hot) fuel in aircraft after landing

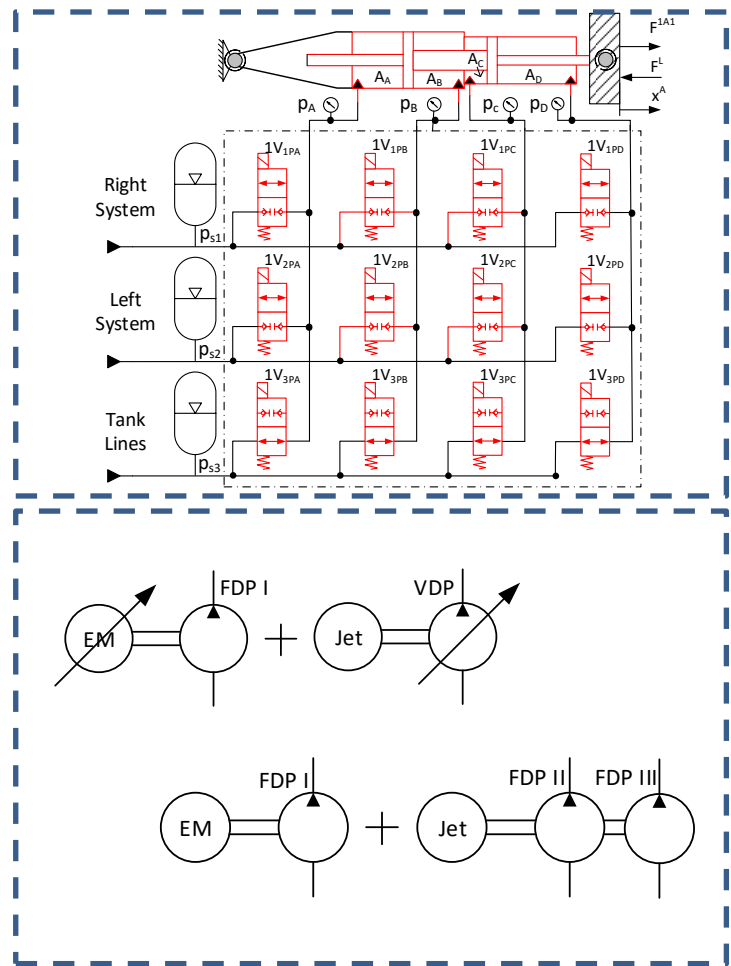
Efficient Hydraulic Hybrid Systems for Aeronautical Applications



Standard Hydraulic Circuit



New Architectures



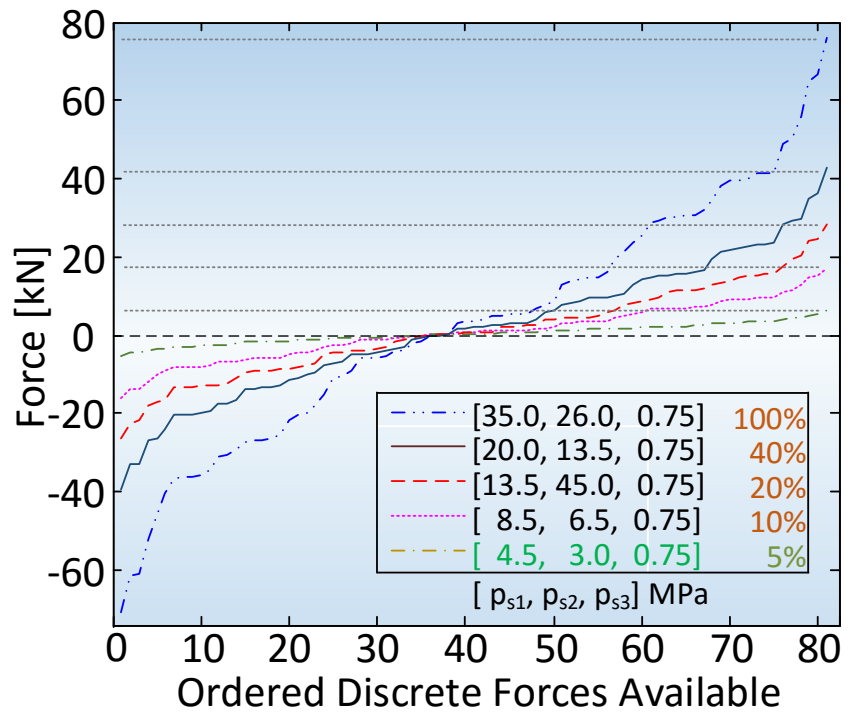
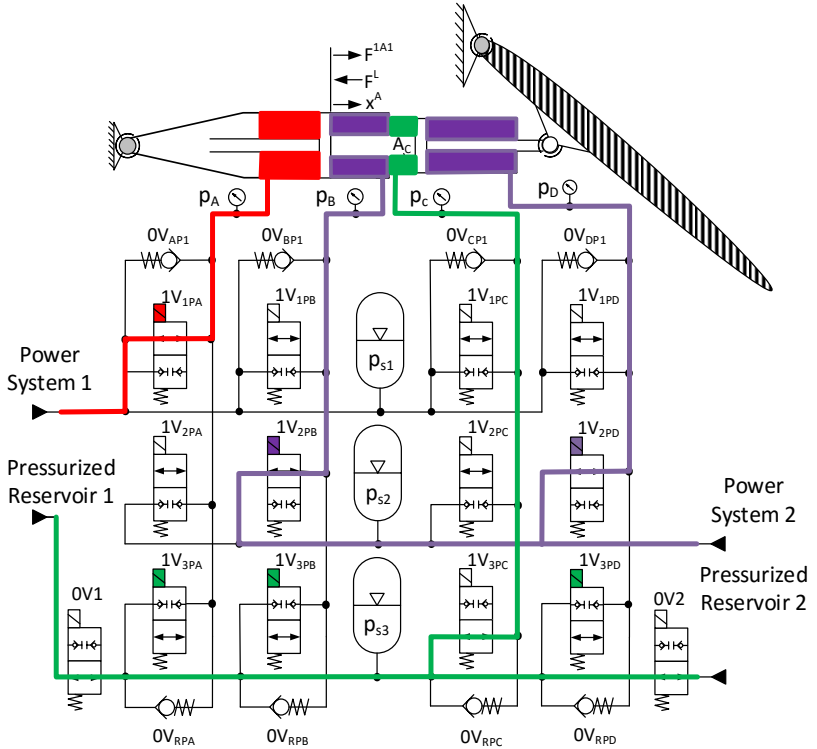
Efficient Hydraulic Hybrid Systems for Aeronautical Applications



Actuation systems based on Digital Hydraulics

- Multi-chamber cylinder
- Twelve on/off-valves
- Two different high-pressure lines
- Two low-pressure lines
- Accumulator

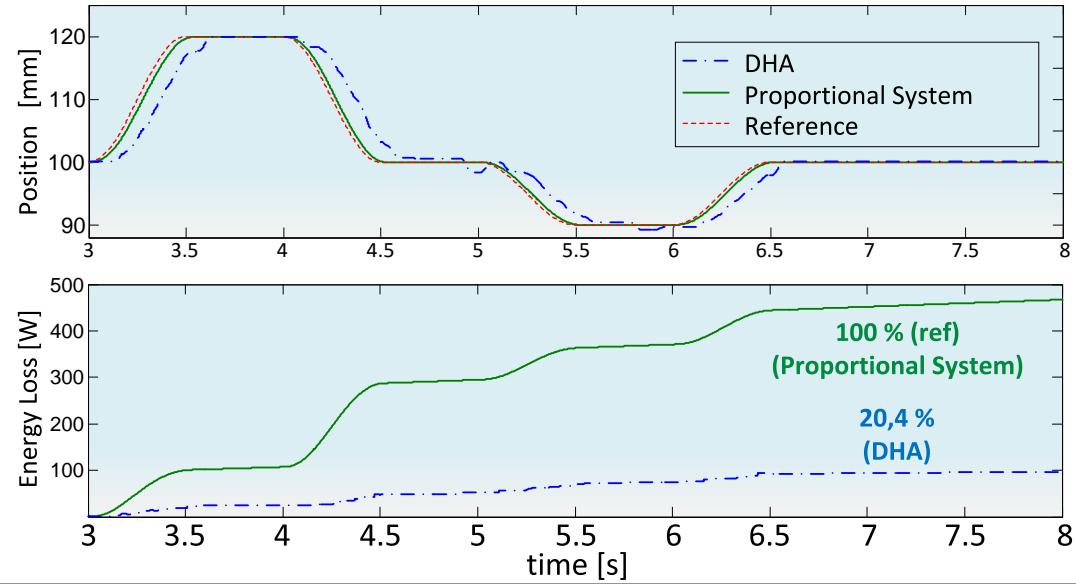
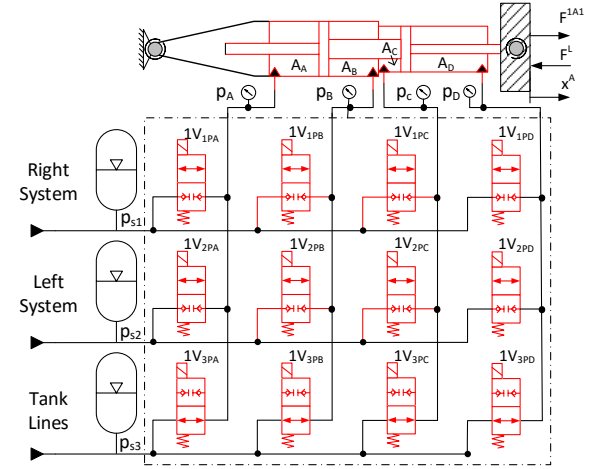
PhD Student (2014-2017)
Henri C. Belan



Efficient Hydraulic Hybrid Systems for Aeronautical Applications



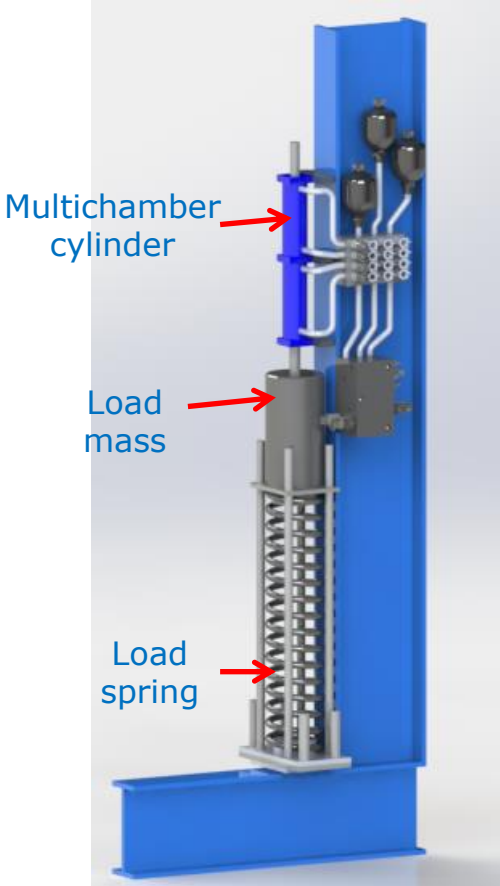
- Preliminary theoretical results
 - Energy losses are 20.4 % of a standard system
 - No resistive throttle control
- Characteristics:
 - Isolation between Hydraulic Systems 1 and 2
 - Optimal choice of supply pressure for the load
 - Two or four chambers can be pressurized



Efficient Hydraulic Hybrid Systems for Aeronautical Applications



- Test rig at LASHIP/UFSC
 - Proof of concept
 - First measurements in May, 2016

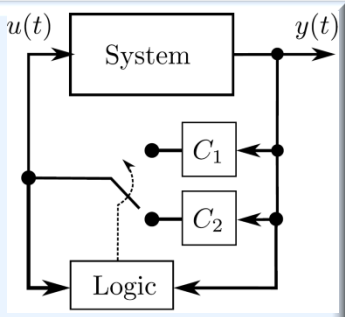


Efficient Hydraulic Hybrid Systems for Aeronautical Applications



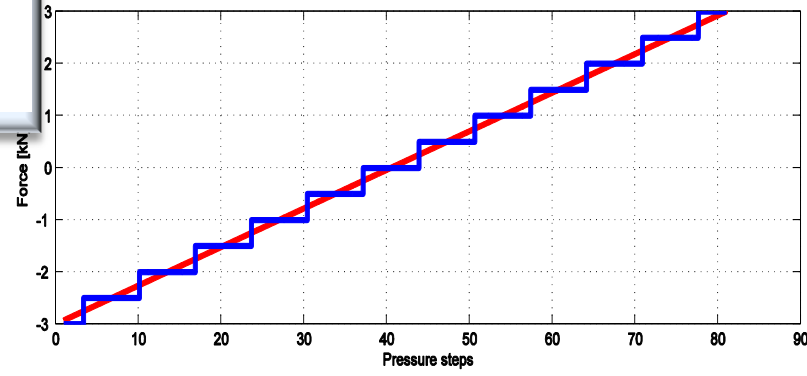
Position control with Digital Actuators

- Switched control theory
- Linearized system with time delay

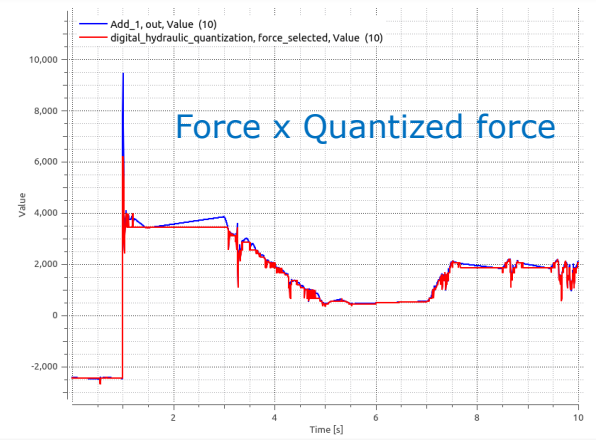
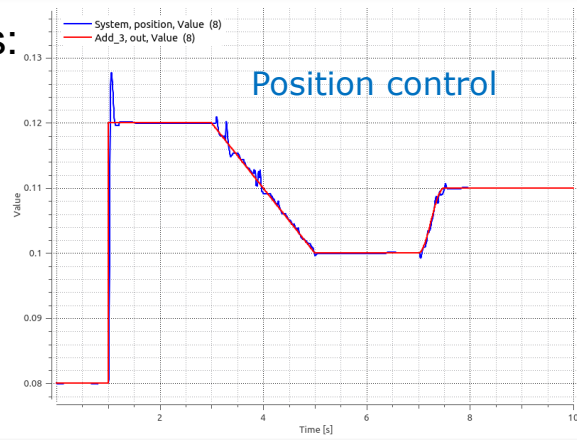


PostDoc (2016)
 Lie Pablo G. Pinto

- Quantization due to valve selection:



- Preliminary results:



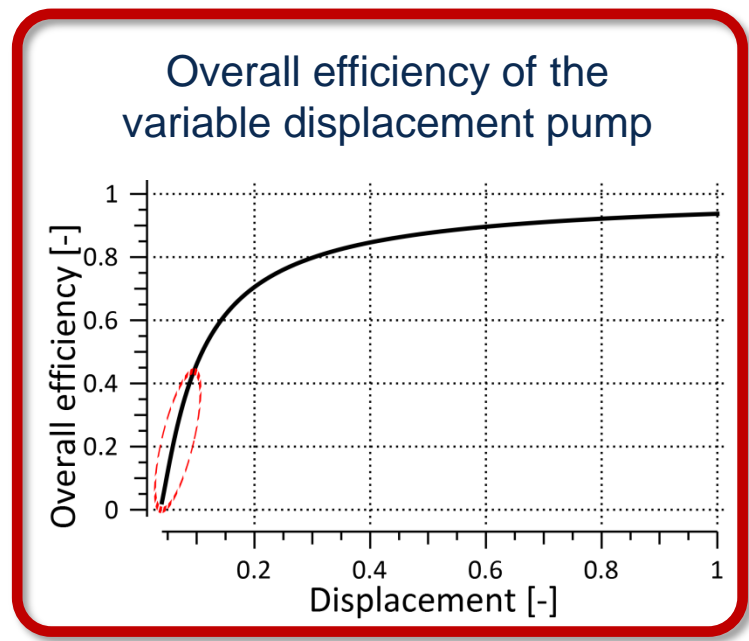
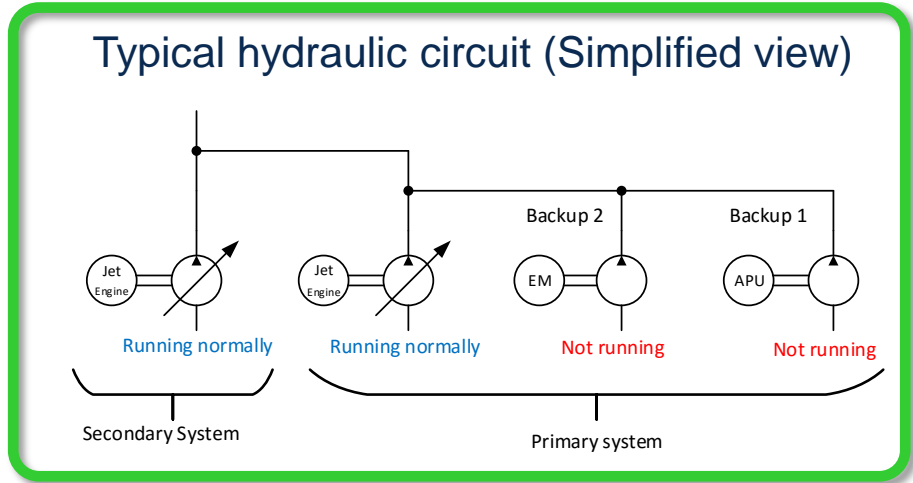


Hybrid Hydraulic Power Units

- Innovative designs for hydraulic power supply units
 - Improve the energetic efficiency:

PhD Student (2014-2017)
Cristiano C. Locateli

- Cruise speed: Variable Displacement Pump working at low volumetric displacement, low flow rate, and high discharge pressure: **LOW EFFICIENCY**





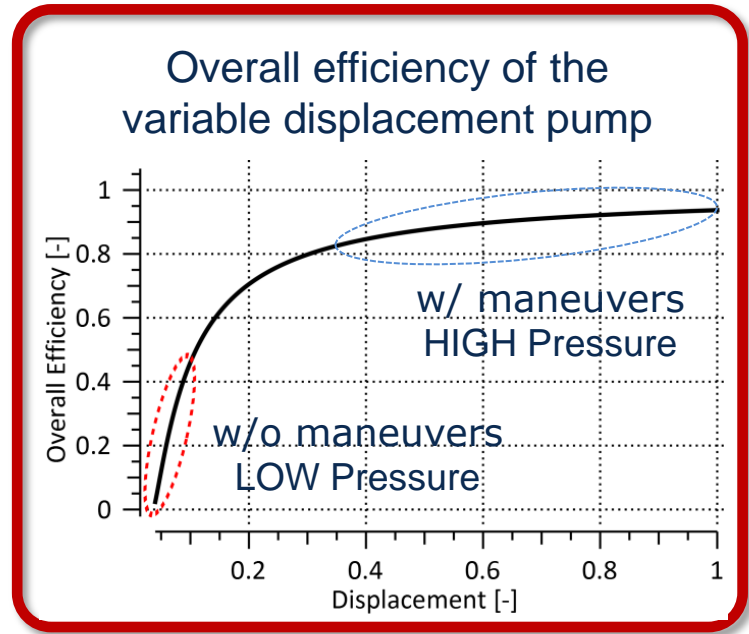
Hybrid Hydraulic Power Units

PhD Student (2014-2017)
Cristiano C. Locateli

Alternative designs

Energy save (%)

		Line	All System
Hydraulic System 1			
I		25,4	12,4
II		20,5	10,0
III		22,0	10,7
IV		25,0	12,2



Efficient Hydraulic Hybrid Systems for Aeronautical Applications

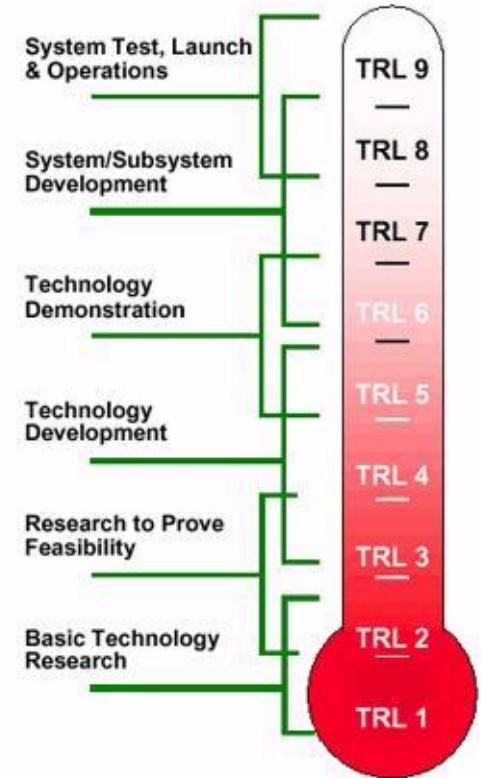


Current Status:

- Project being executed by PhD students and PostDoc
- Financial resources for personal mobility from CNPq, SAAB, CISB
- Financial resources for test rig construction from Brazilian research call (FAPESC) and LASHIP/FLUMES resources

- Proof of concepts being built at university
- Focused on the application requirements

• TRL 3, 4





Next Step: Case 1

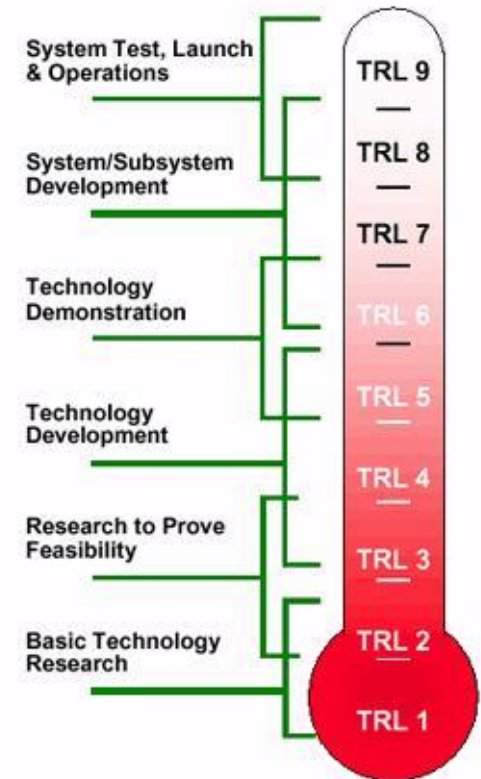
▪ Joint Brazilian-Swedish calls from research agencies

- Resources for test rig construction
- Scholarships for undergraduate & graduate students
- Team mobility: Experiences at SAAB, LiU and UFSC
- Expand the research activities
- Proof of concepts for additional research problems

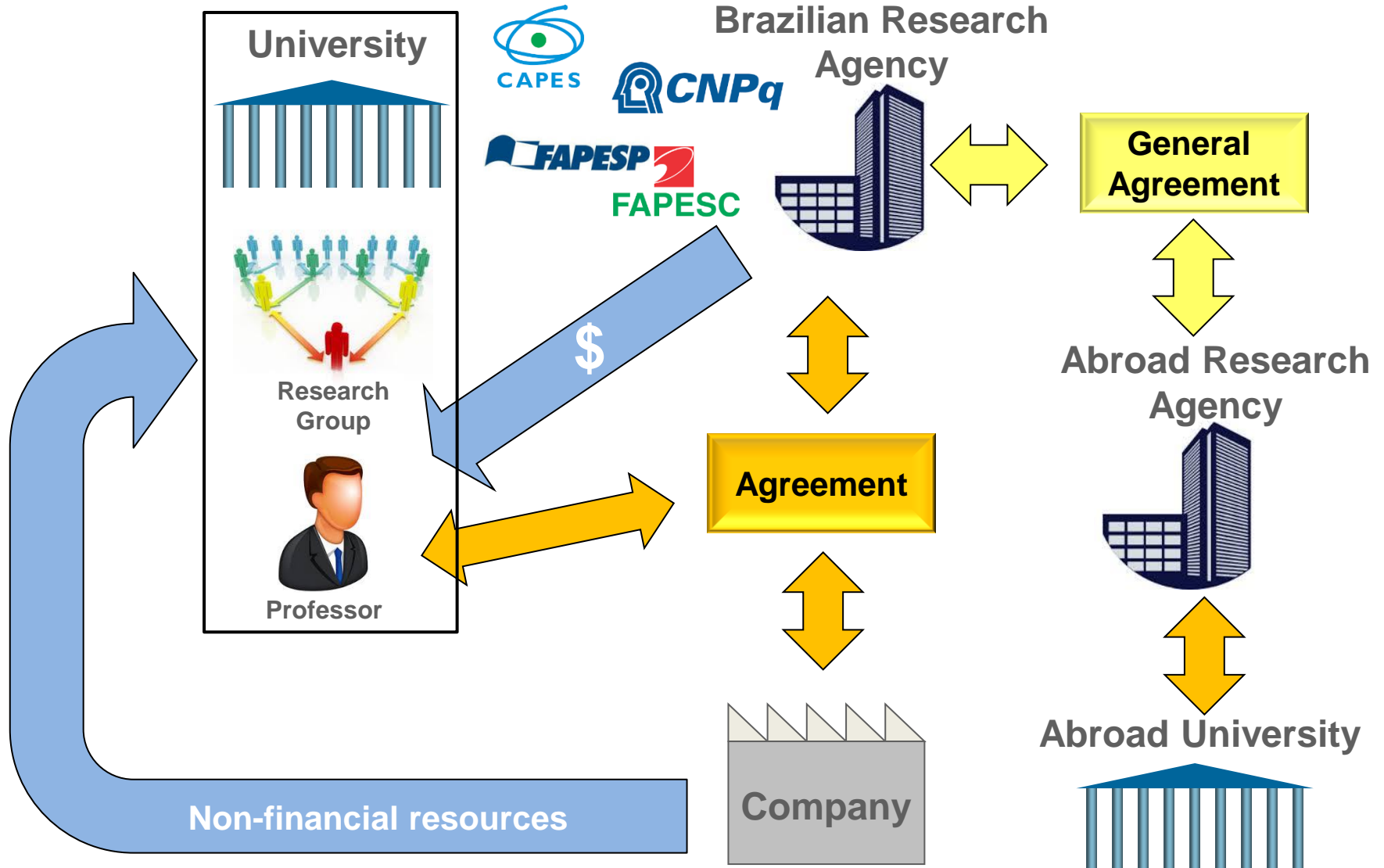
▪ Projects of small or medium sizes

- Allows to keep the team working
- Contract direct with the professor: less bureaucracy

▪ TRL 3, 4



Industrial Research Project Funded by Research Agency





Next Step: Case 2

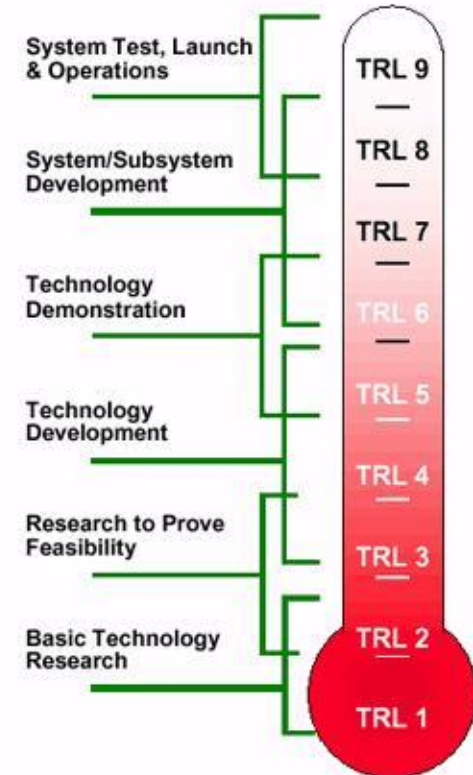
Research projects supported by funding agencies and industry

- Include the study of additional requirements:
 - Reliability analysis
 - Safety
 - Impact on aircraft weight
- Prototype System
- Use of aircraft components



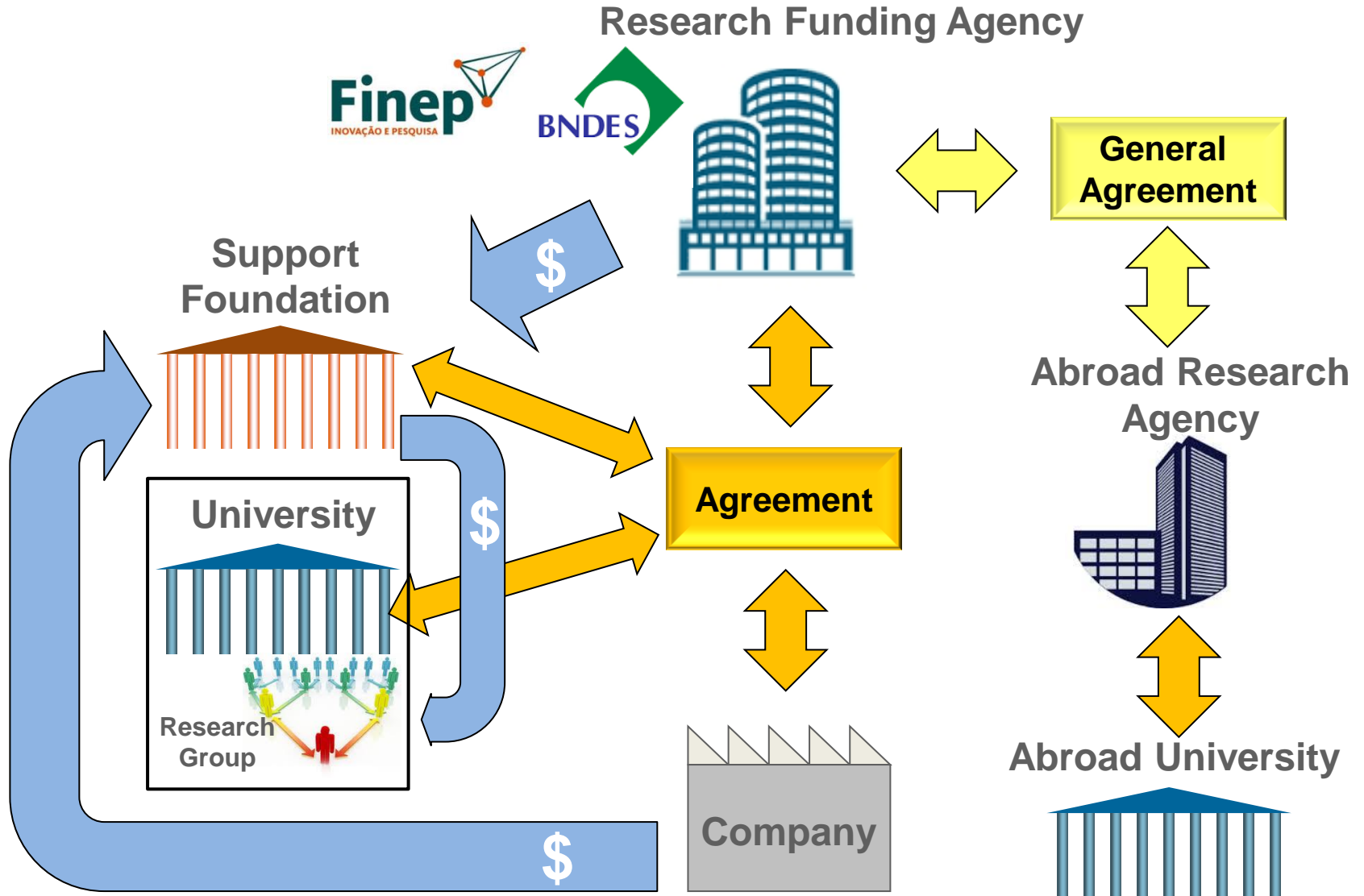
Projects of medium or large sizes

- Improve the laboratory infrastructure
- Full time participation of researchers at university
- Increase participation of industry researchers and engineers



TRL 5, 6

Industrial Research Project Funded by Funding Agency



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