CISB | CENTRO DE PESQUISA E INOVAÇÃO SUECO-BRASILEIRO

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

EMC - UFSC LASHIP HYDRAULICS & PNEUMATICS

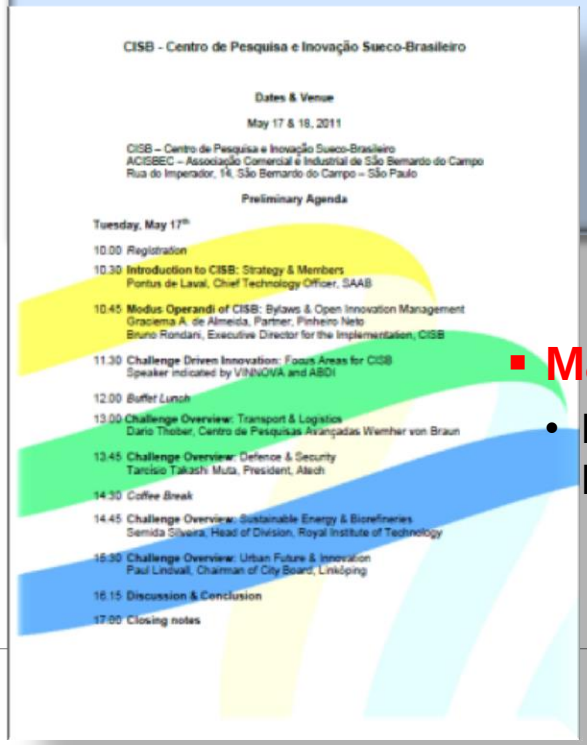
Outline

- 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

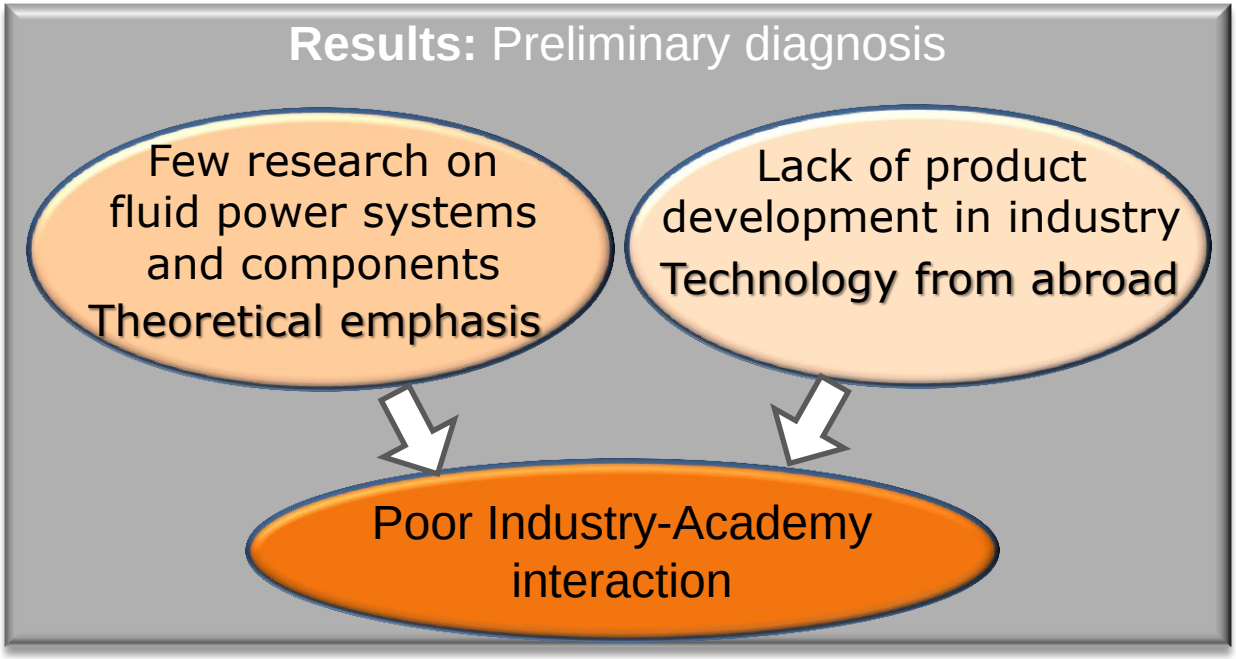
Preliminary Agenda

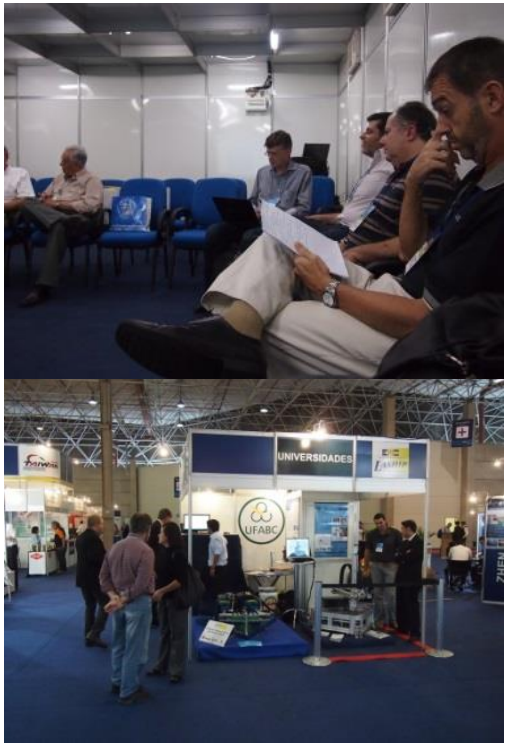
Tuesday, May 17th

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 *Buffet Lunch*
13.00 **Challenge Overview:** Transport & Logistics
Dario Thober, Centro de Pesquisas Avançadas Wernher von Braun
13.45 **Challenge Overview:** Defence & Security
Tancisio Takashi Muta, President, Atech
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 Lindvall, Chairman of City Board, Linköping
16.15 **Discussion & Conclusion**
17.00 **Closing notes**

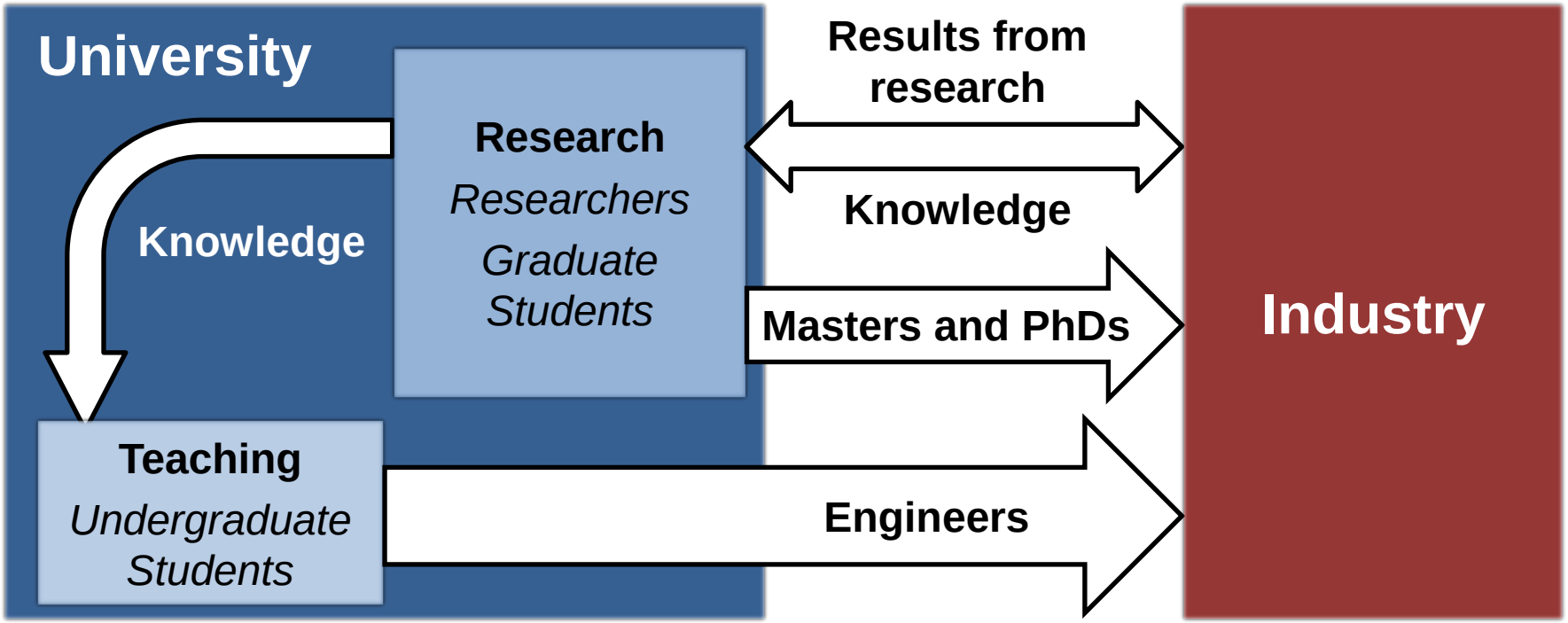
- **May, 2011** – São B. do Campo, São Paulo
  - **Inauguration of the Swedish-Brazilian Research and Innovation Centre (CISB)**

- **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



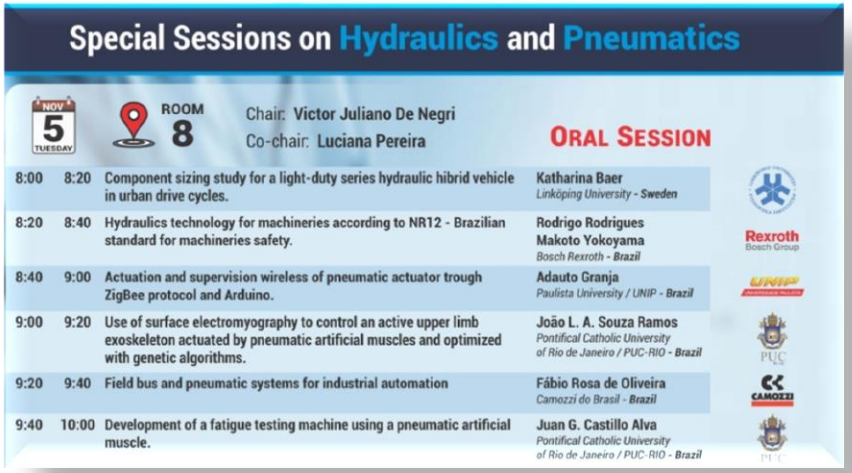


- **ABIMAQ/CSHPA (Chamber of Hydraulics, Pneumatics, and Automation Systems)**
  - Discussion about:
    - Actions for Teaching, Research and Innovation
    - Opportunities for R&D funding in industry



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



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

Speeches about University-Industry Experiences

- **Workshops organized by UFABC:**
  - **Chairperson: Prof. Luciana Pereira**
  - Speakers: Prof. Petter Krus, Prof. Victor De Negri

iLab@UFABC

- 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**

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:

FAPESC

LINKÖPING UNIVERSITY

UFABC

UFSC

EMBASSY OF SWEDEN
Brasília

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SAAB

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

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

Organization of Swedish-Brazilian Workshops

- **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

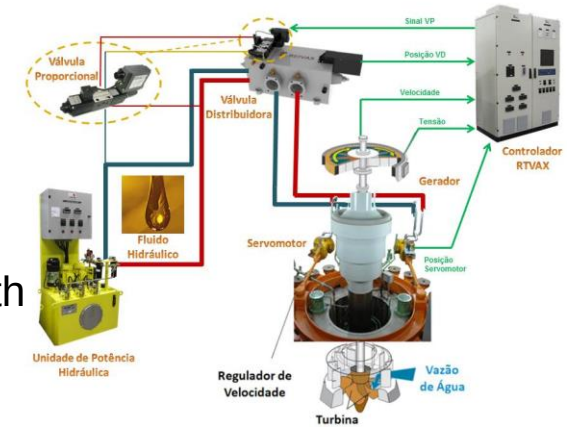
- 9th FPNI Ph.D. Symposium
  - Organized by:
  - 26-28 October
  - Invited speakers from industry and academy
  - Paper presentations by Master's and Ph.D. students
  - Audience: Graduate students, researchers, and professors

Collaboration on Research Projects

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

REIVAX

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico



    - 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

nedip

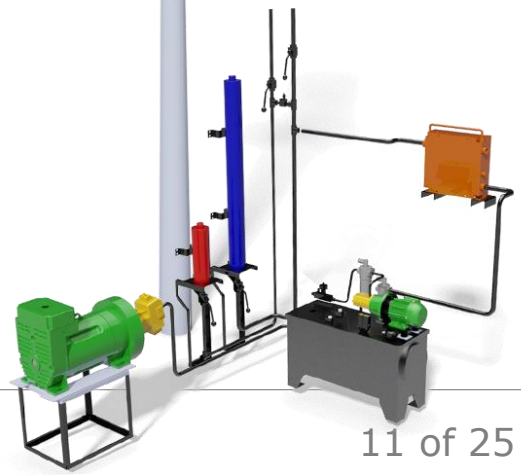
Fluida och Mekatroniska System FluMeS Fluid and Mechatronic Systems

FAPESC

LASHiP HYDRAULICS & PNEUMATICS

REIVAX

Parker



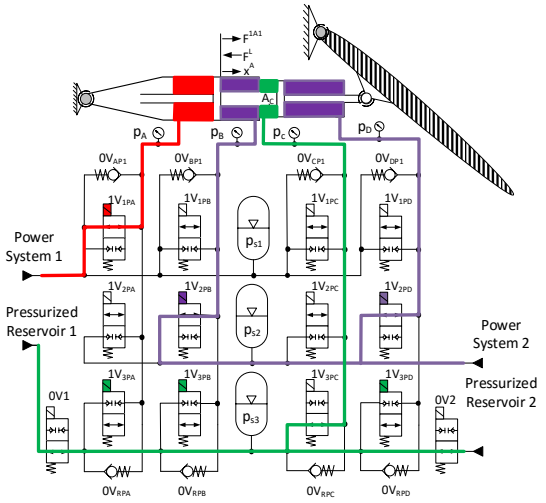
Efficient Hydraulic Hybrid Systems for Aeronautical Applications

- 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

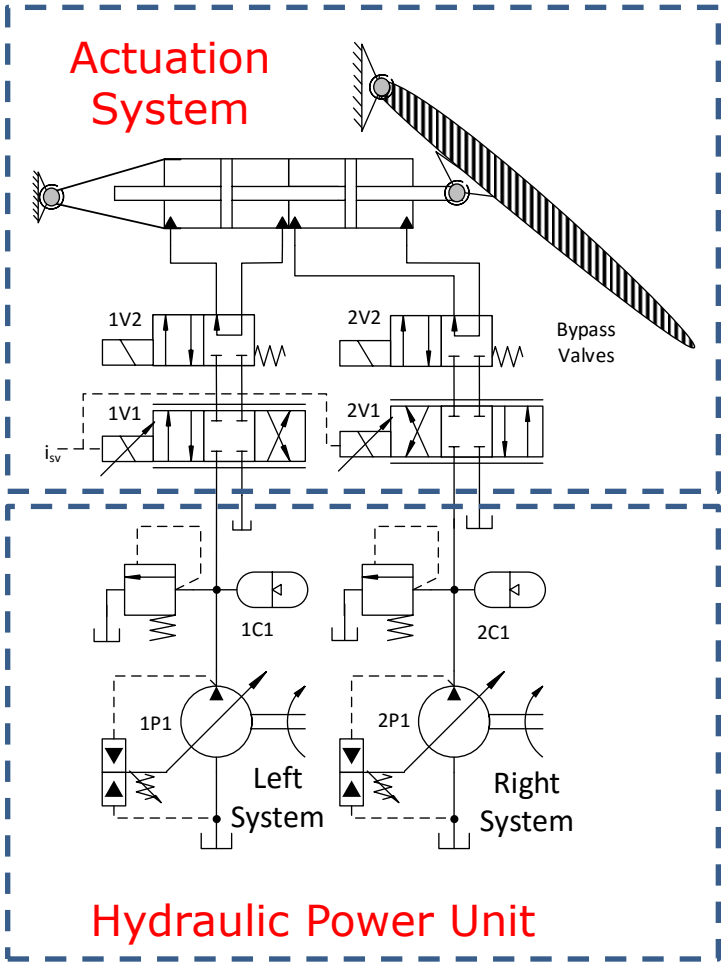


Efficient Hydraulic Hybrid Systems for Aeronautical Applications

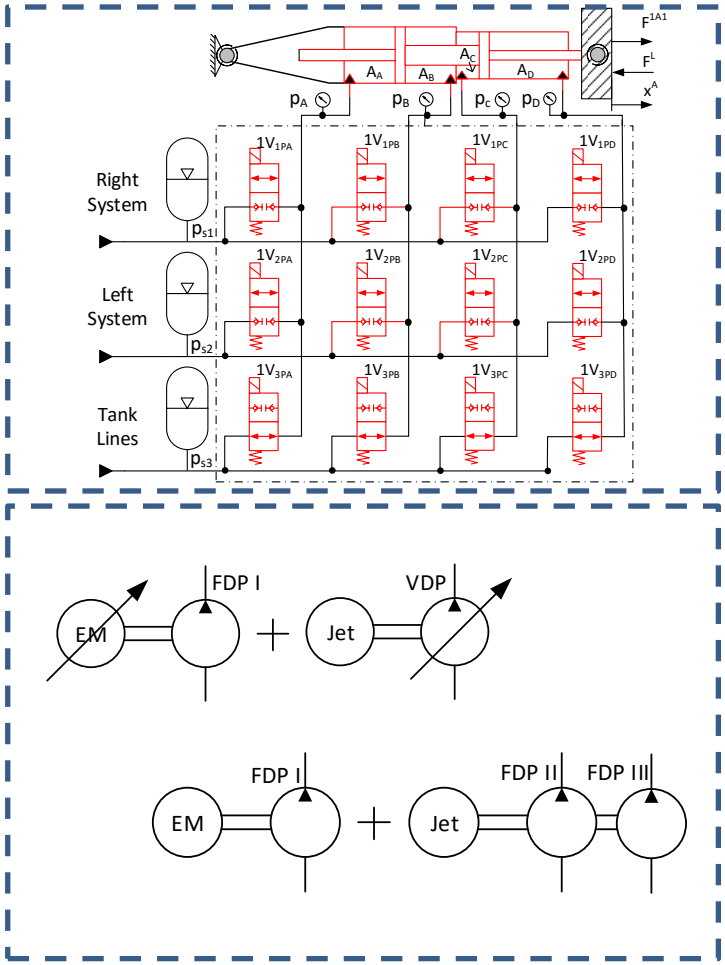
- Development of innovative hydraulic systems with increased energy efficiency for aircraft onboard systems
  - Focus on flight control actuation:
    - Actuation systems
    - Hydraulic power unit
  - Impact on the aircraft hydraulic architecture

- 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

Standard Hydraulic Circuit



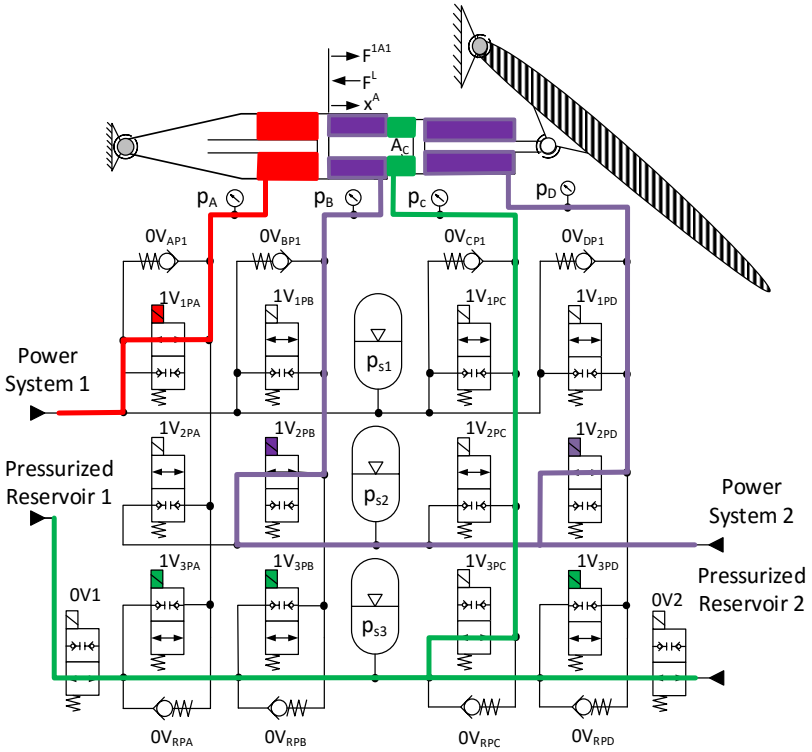
New Architectures

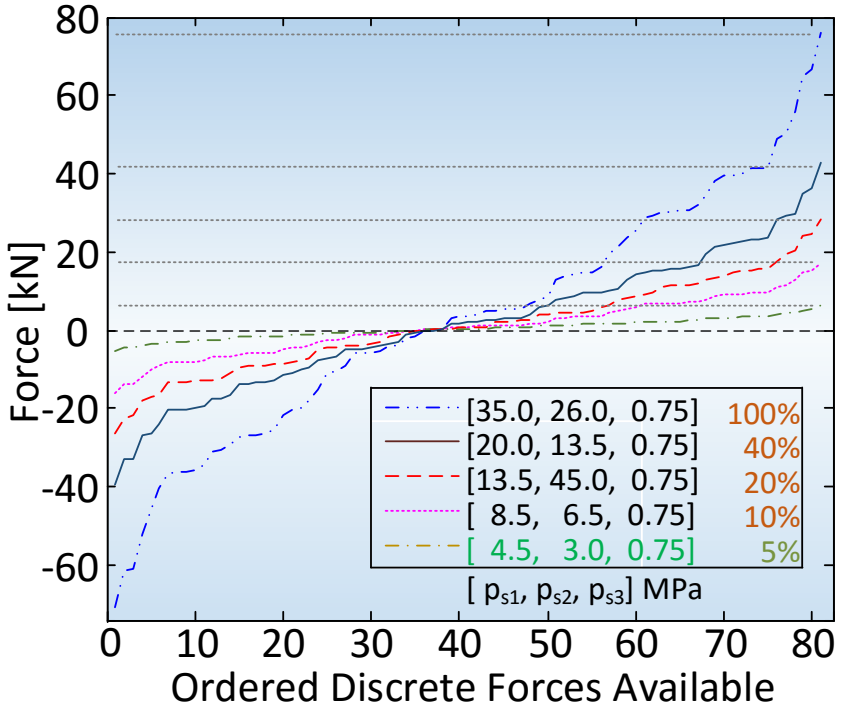


Efficient Hydraulic Hybrid Systems for Aeronautical Applications

- **Actuation systems** based on **Digital Hydraulics**
  - Multi-chamber cylinder
  - Twelve on/off-valves
  - Two different high-pressure lines
  - Two low-pressure lines
  - Accumulator

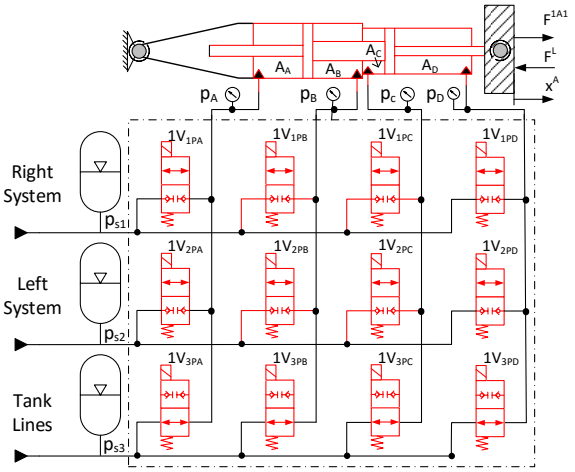
PhD Sudent (2014-2017)
Henri C. Belan

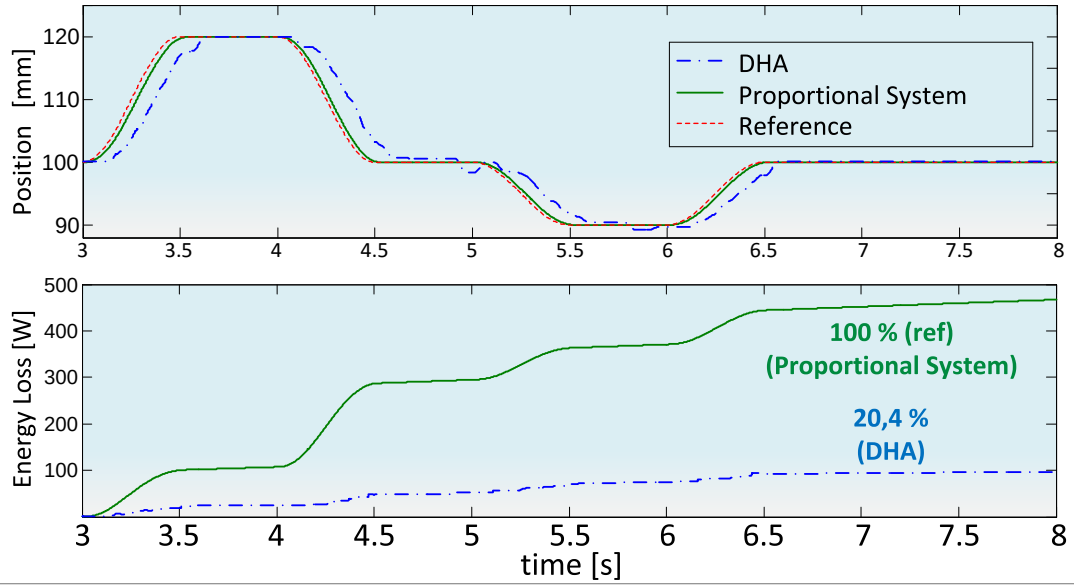




Efficient Hydraulic Hybrid Systems for Aeronautical Applications

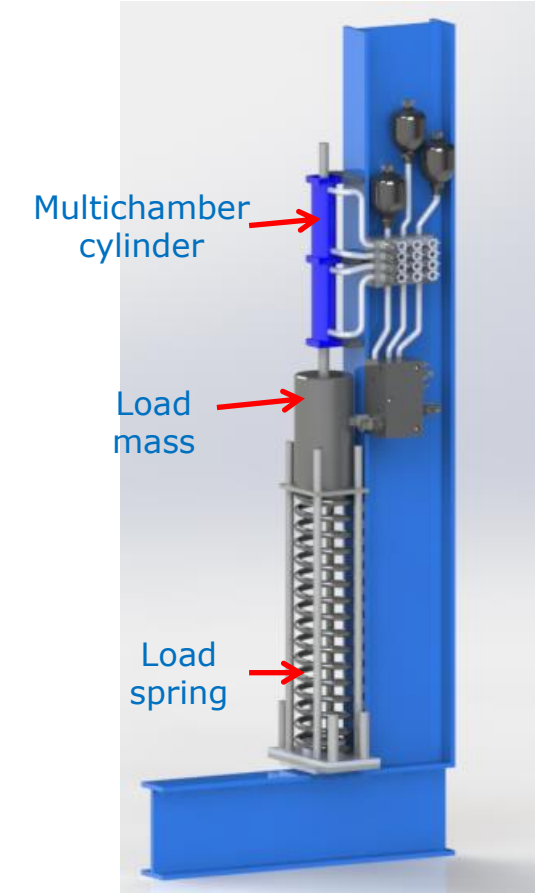
- Preliminary theoretical results
  - Energy losses are 20.4 % of a standard system
  - No resistive throttle control
- Characteristics:
  - Isolation between Hydraulic Systems 1 and 2
  - Optimal choice of supply pressure for the load
  - Two or four chambers can be pressurized





Efficient Hydraulic Hybrid Systems for Aeronautical Applications

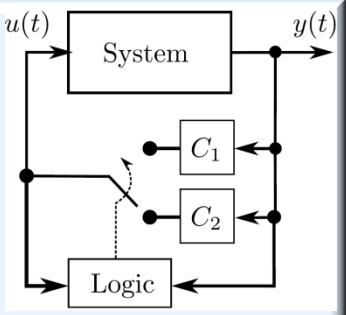
- Test rig at LASHIP/UFSC
  - Proof of concept
  - First measurements in May, 2016



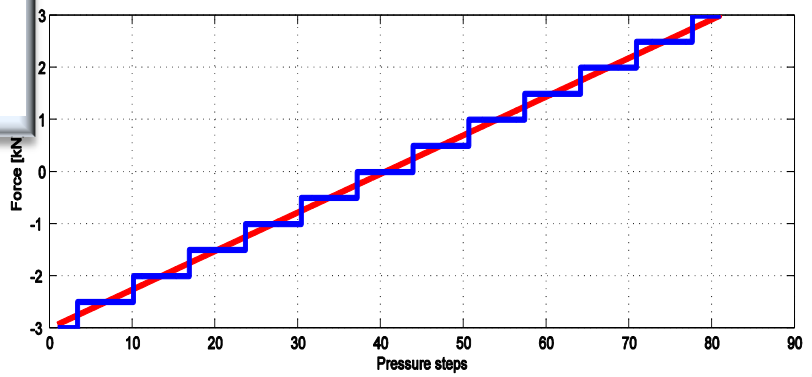
- **Position control with Digital Actuators**

PostDoc (2016)
Lie Pablo G. Pinto

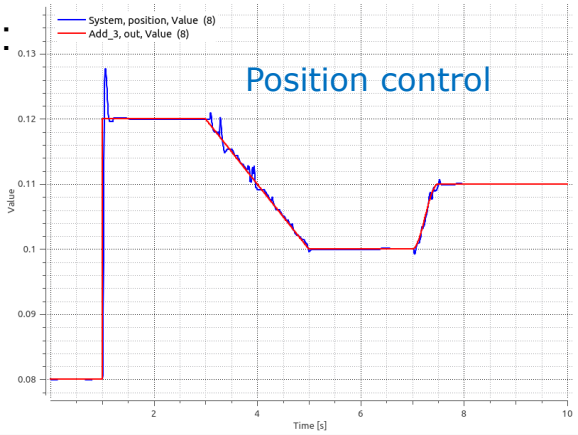
- Switched control theory
- Linearized system with time delay

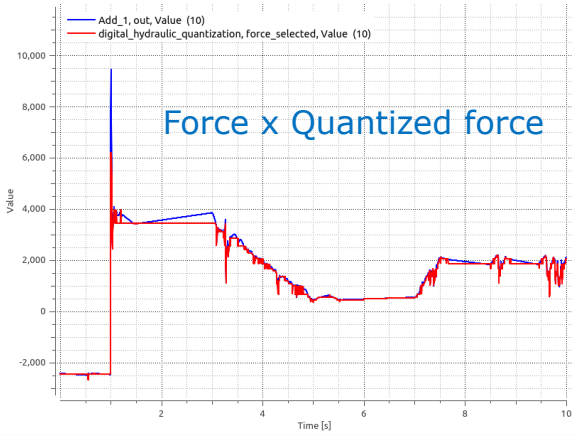


- Quantization due to valve selection:



- Preliminary results:





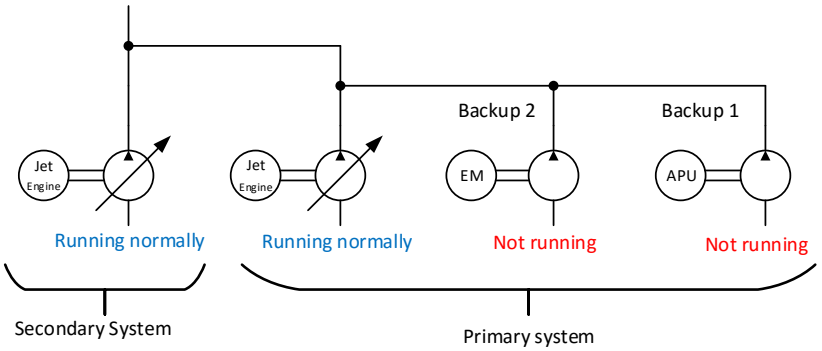
Efficient Hydraulic Hybrid Systems for Aeronautical Applications

- **Hybrid Hydraulic Power Units**
  - Innovative designs for hydraulic power supply units
    - Improve the energetic efficiency:

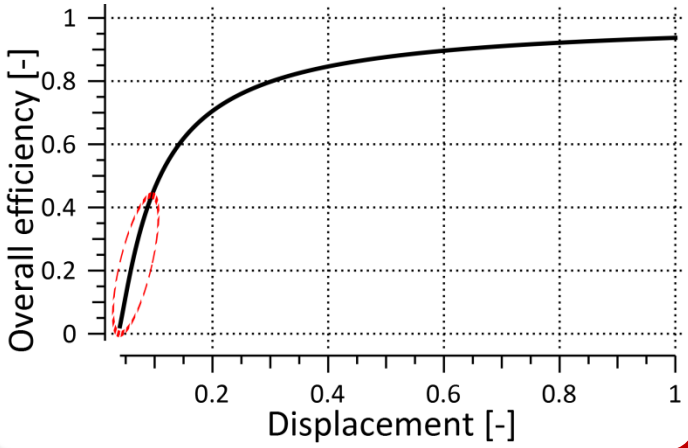
PhD Sudent (2014-2017)
Cristiano C. Locateli

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

Typical hydraulic circuit (Simplified view)



Overall efficiency of the variable displacement pump



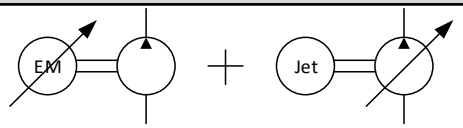
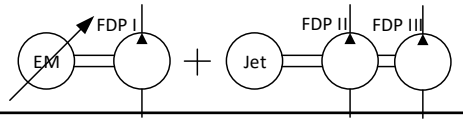
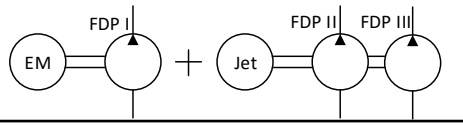
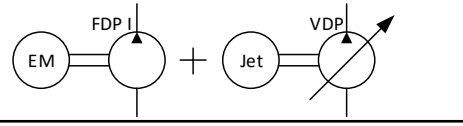
Efficient Hydraulic Hybrid Systems for Aeronautical Applications

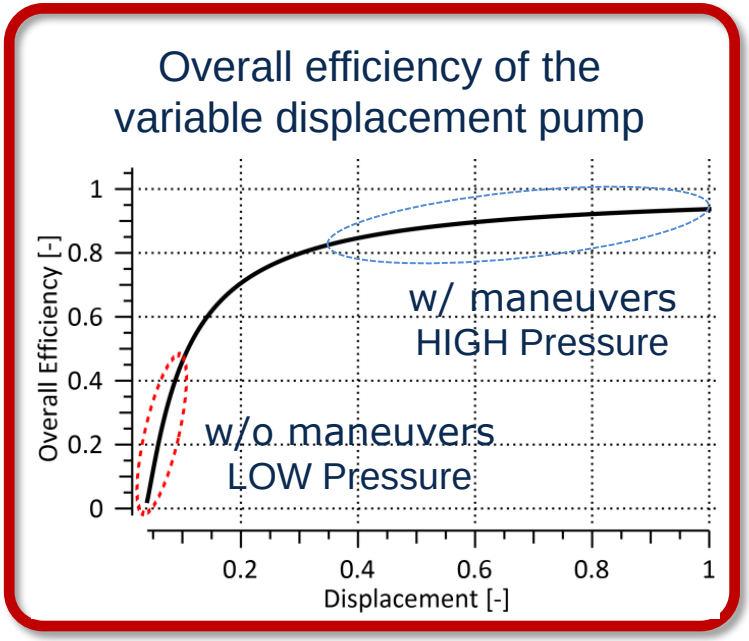
- **Hybrid Hydraulic Power Units**

PhD Sudent (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

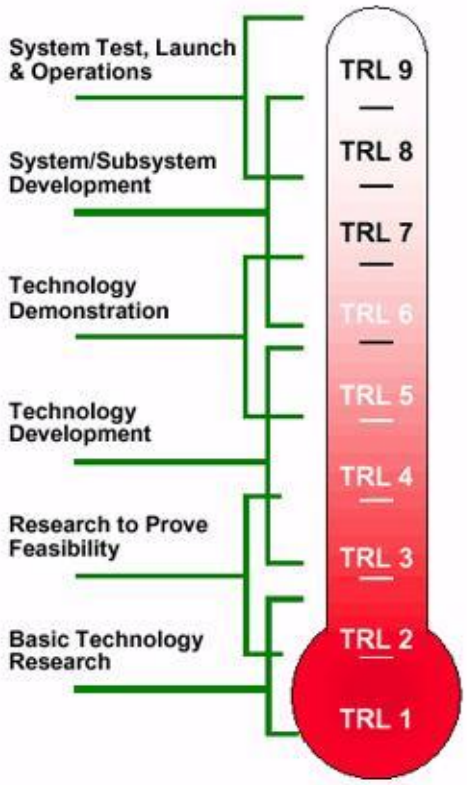


Efficient Hydraulic Hybrid Systems for Aeronautical Applications

- **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**

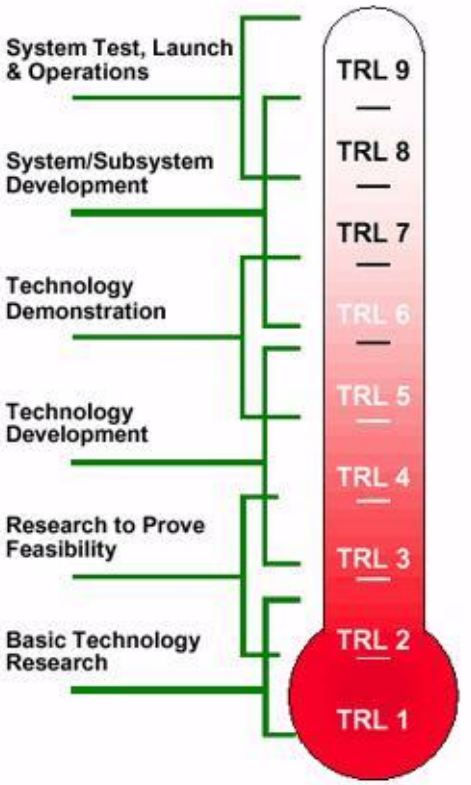


Next Step: Case 1

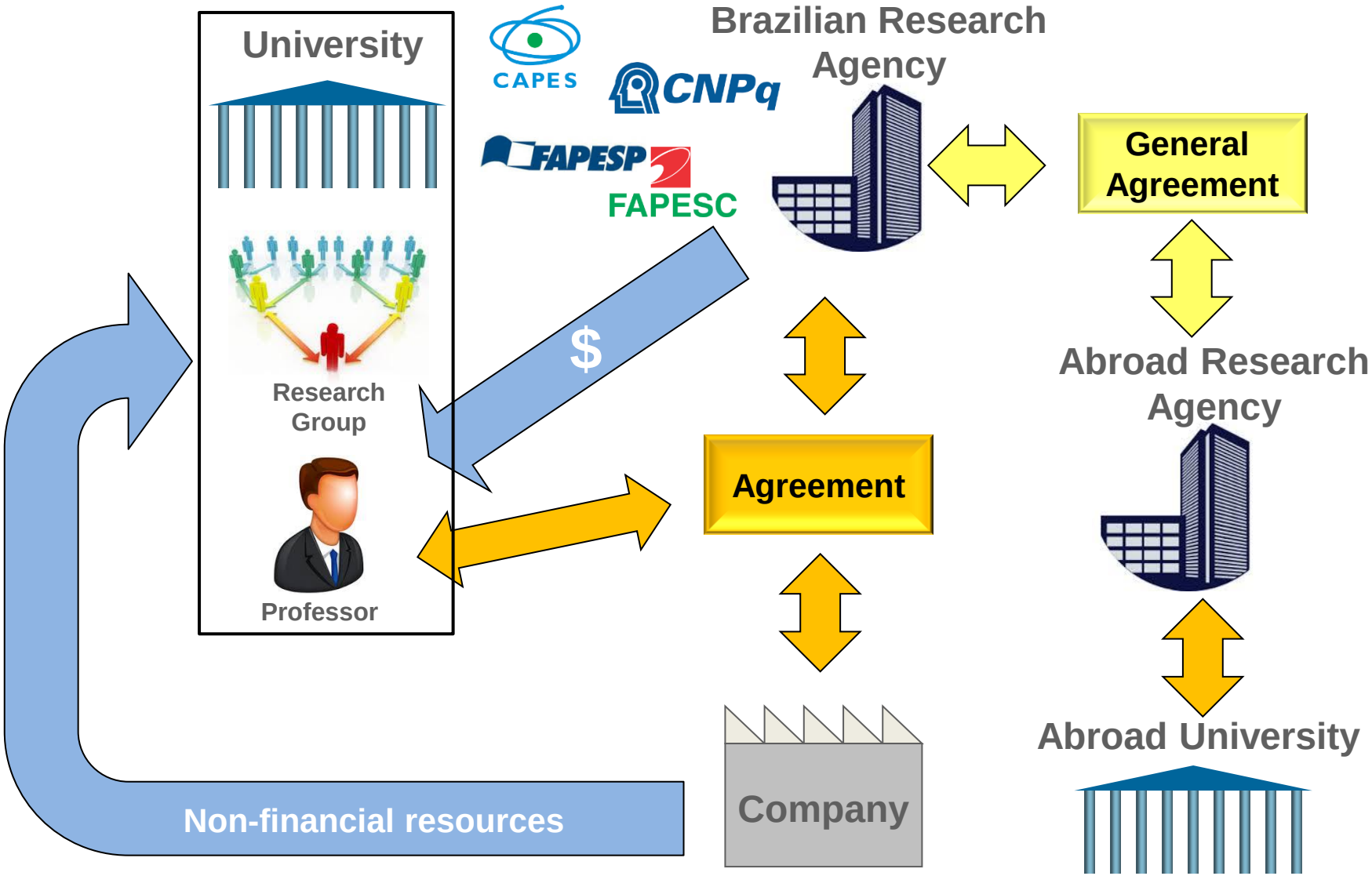
- **Joint Brazilian-Swedish calls from research agencies**
  - Resources for test rig construction
  - Scholarships for undergraduate & graduate students
  - Team mobility: Experiences at SAAB. LiU and UFSC
  - Expand the research activities
  - Proof of concepts for additional research problems

- **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

SAAB

- **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

BNDES

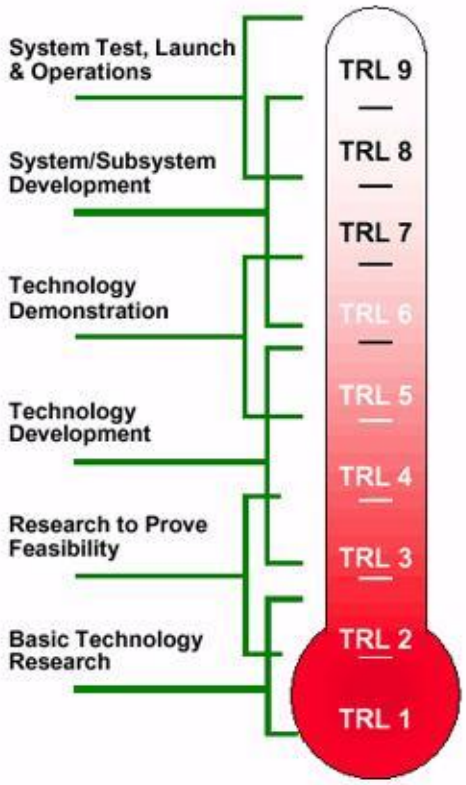
Finep
INOVAÇÃO E PESQUISA

- **Projects of medium or large sizes**
  - Improve the laboratory infrastructure
  - Full time participation of researchers at university
  - Increase participation of industry researchers and engineers

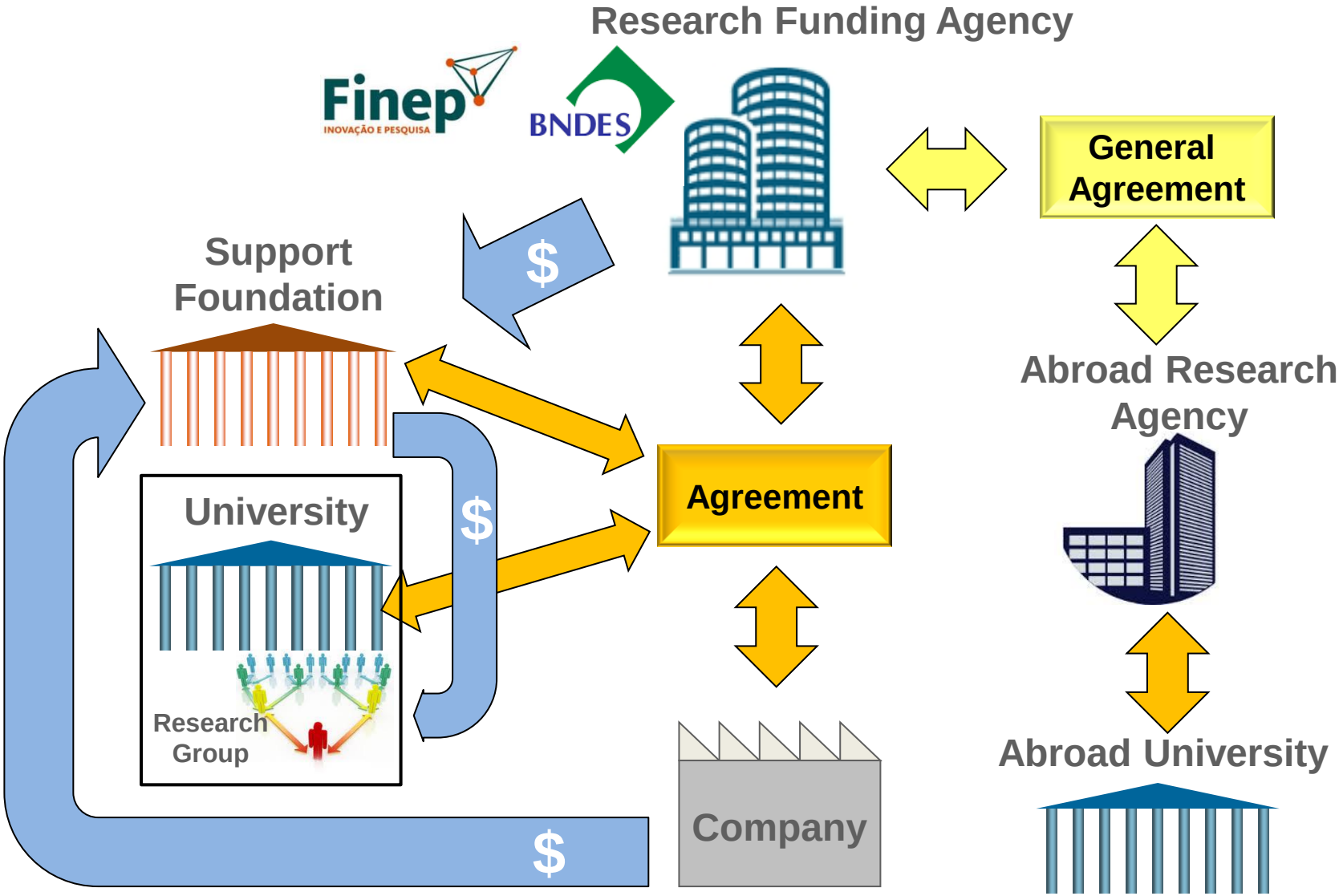
VINNOVA

- **TRL 5, 6**

SAAB



Industrial Research Project Funded by Funding Agency



Seminar in Aeronautics

Brasília, May 16, 2016

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

Prof. Victor J. De Negri
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