In4073
Embedded Real-Time Systems

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Embedded Software Lab

About the Instructor

- BSc Physics Engineering
- MSc and PhD Computer Science

- DSM (Embedded Systems, Electronics)
- TNO (High-Performance Computing)
- TUD (EE, Computer Engineering)
- TUD (CS, Embedded SW, 0.4 fte)

- Live in Ravenswoud (Fr)
- http://www.st.ewi.tudelft.nl/~gemund

Outline

1. Embedded Systems
2. Course Goal
3. Lab Project

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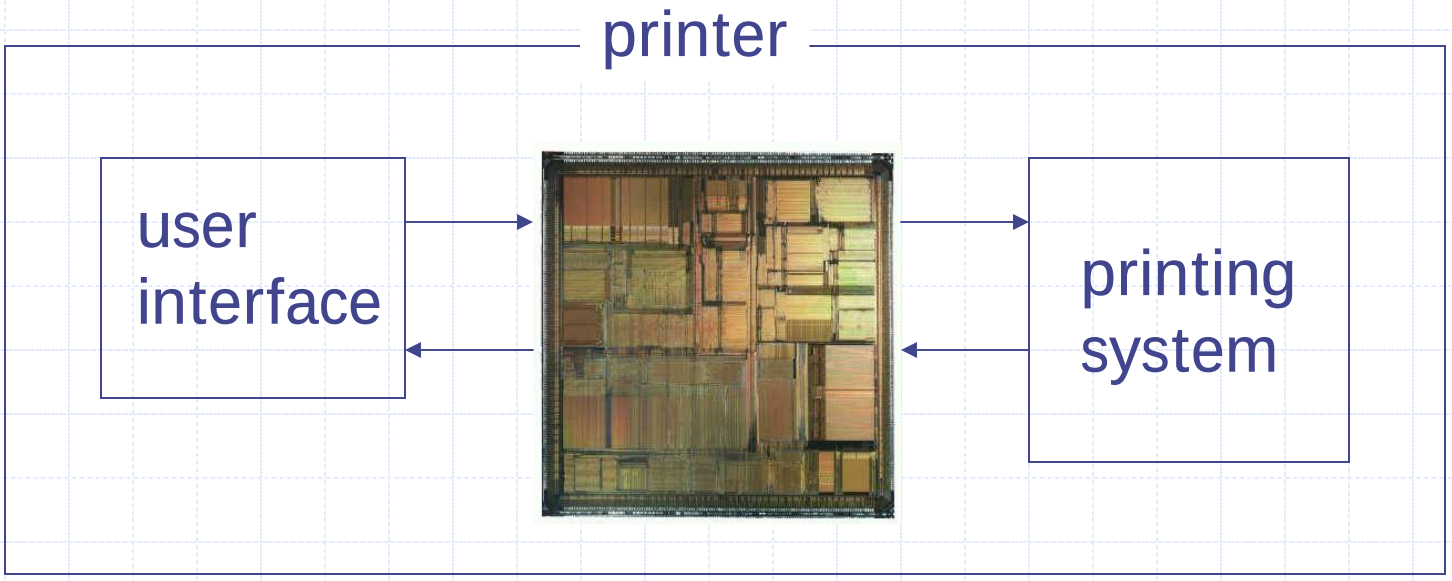
Embedded System

ES = computer system
embedded within other system
defining its functionality



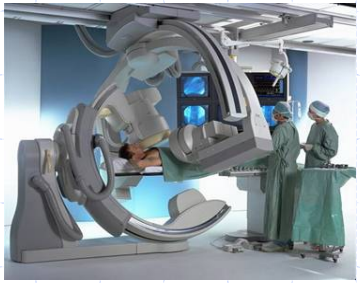
Example Systems

- Phone, cam, audio, VCR, TV, PDA, games ..
- Heater, refrigerator, μwave, airco, ..
- Printer, copier, fax, modem, comm hub, ..
- Car engine, brakes, CC, car navig, ..
- Missiles, planes, subs, ships, trains, ..
- Power plants, chemical plants, ..
- Wafer scanners, medical devices, ..



Embedded Systems Boom

- Provides functionality of almost everything
- 100 times PC market size
- 25% annual growth rate (E Linux > 60%)
- Accounts for 25-40% costs in automotive
- In society's critical path
- Must be dependable, but affordable



ES Technology Today

- µproc + peripheral I/O (boards, racks)
- µcontroller (all on single chip)
- DSP (idem, optimized for signal proc)
- FPGA (idem, no ISA)
- ASIC (idem, not programmable)

- Shift from HW to SW (> 10 MLOC in ConsElec)
- in4073: Focus on Embedded *Software*

Embedded Software Crisis

- TV, mobile phone, car: > 10 MLOC
- Code complexity is growing exponentially
- Number of bugs is growing exponentially
- Despite good SW eng'g 1 – 10 bug / KLOC
- Therac-25, Ariane 5, USS Yorktown, Mars Climate Orbiter, Mars Polar Lander, Patriot your car ..?
- 100 G$ / yr on bug costs
- Embedded SW is difficult!

What's so Special About ES?

- Tight interaction with embedding system
- Real-time response
- Adequately react to unpredictable events
- Cope with failures of embedding system

- Physics (electronics, optics, mechanics, ..)
- Concurrency
- Performance
- Power
- Dependability

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Course Goal

- Introduction to multidisciplinary design
- Work with embedded SW
- For CS to get comfortable with embedded HW, Physics, Signals, Control, ...
- For EE, CE, .. to get comfortable with Emb SW
- For ES bit of both, mandatory course
- Focus: SW instead of HW
- HW: programmable (reconfigurable, cheap)
- Allows you to do ES as personal hobby

Course Format

- Lab + supporting lectures
- Case: embedded control unit for a QR UAV
  - Physics, electronics, control (SW), communication (SW), simulation (SW)
- Technology: PC (Linux/C), FPGA (Emb. C)
- Lab teams (~ 4 students)
- Team types: ES-only, mixed-CS-CE-EE-XX
- Project deliverables: Demonstrator + TR
- Grading: deliverables + ranking + individual
- Grading: 0.75 D + 0.25 T iff $D \geq 50$, $T \geq 50$

Course Support

- Lecture material: course site + WWW
- Lab assignment: course site
- Assignment: your problem … so be pro-active, dig up knowledge yourself, and ASK!
- Course site: Resource page
- Lab facilities: Drebbelweg, room DW 0-210
  - Three 4-hr slots (Thu, Fri, Fri) / 7 weeks
  - Lab Leader: Andreas Loukas
  - 2 TAs: Gonçalo Bernardo, Antonio Ramos

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Project: QR Controller

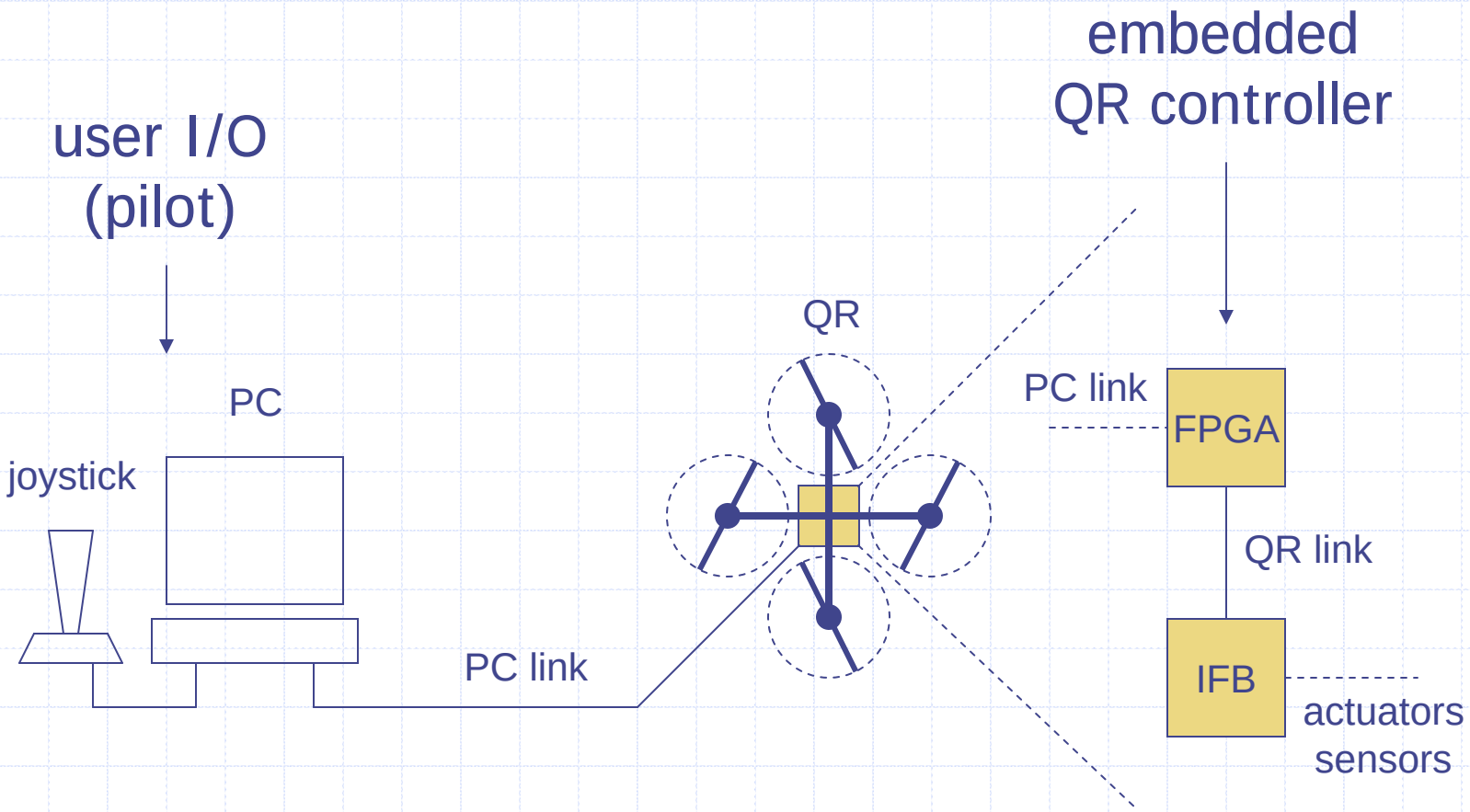
- Electrical model quad-rotor AV (“QR”)
- QR: no stabilization, just rotors + sensors
- Lab goal: roll, pitch, yaw stabilization
- Long-term goal: autonomous UAV

- Experimental sequence:
  - Control from PC
  - Yaw stabilization
  - Roll, pitch stabilization

Hardware of Choice

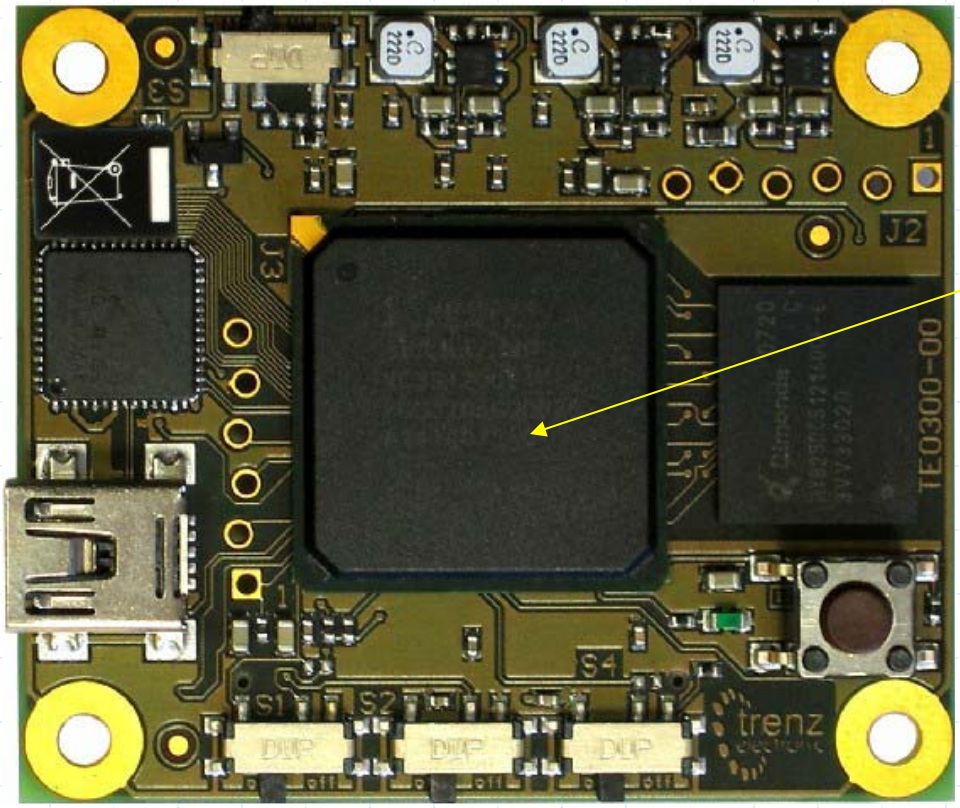
- Linux PC: user I/O (JS, Data Visualization)
- Embedded system alternatives:
  - PC I/O card: expensive, inflexible
  - μcontroller: cheap but inflexible
  - ASIC: even worse
  - FPGA card: cheap, reconfigurable:
    - app-specific μcontroller (VHDL/C)
    - build VM stack from gates upward
    - X32 soft core as lab platform

System Setup

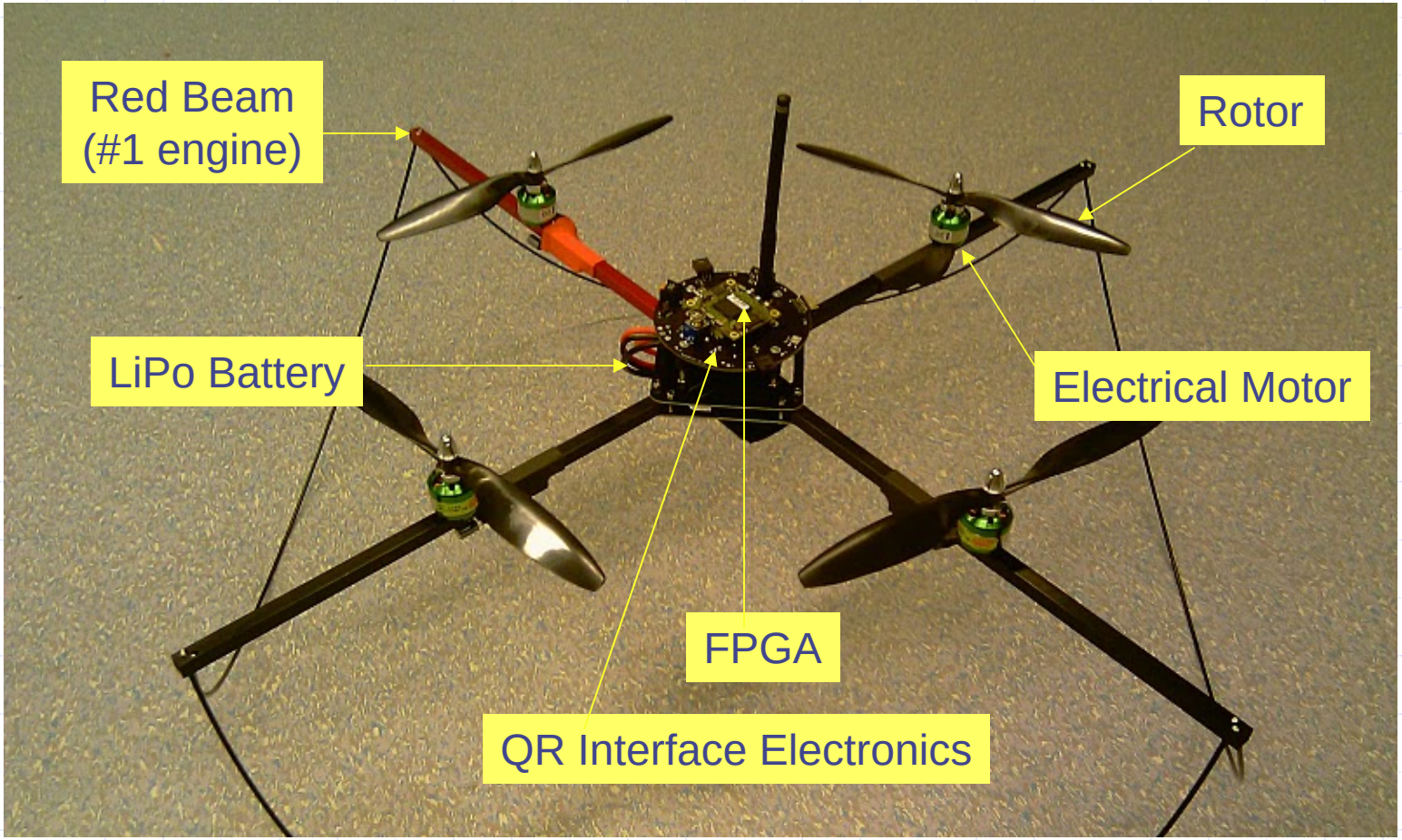


(source: assignment.pdf)

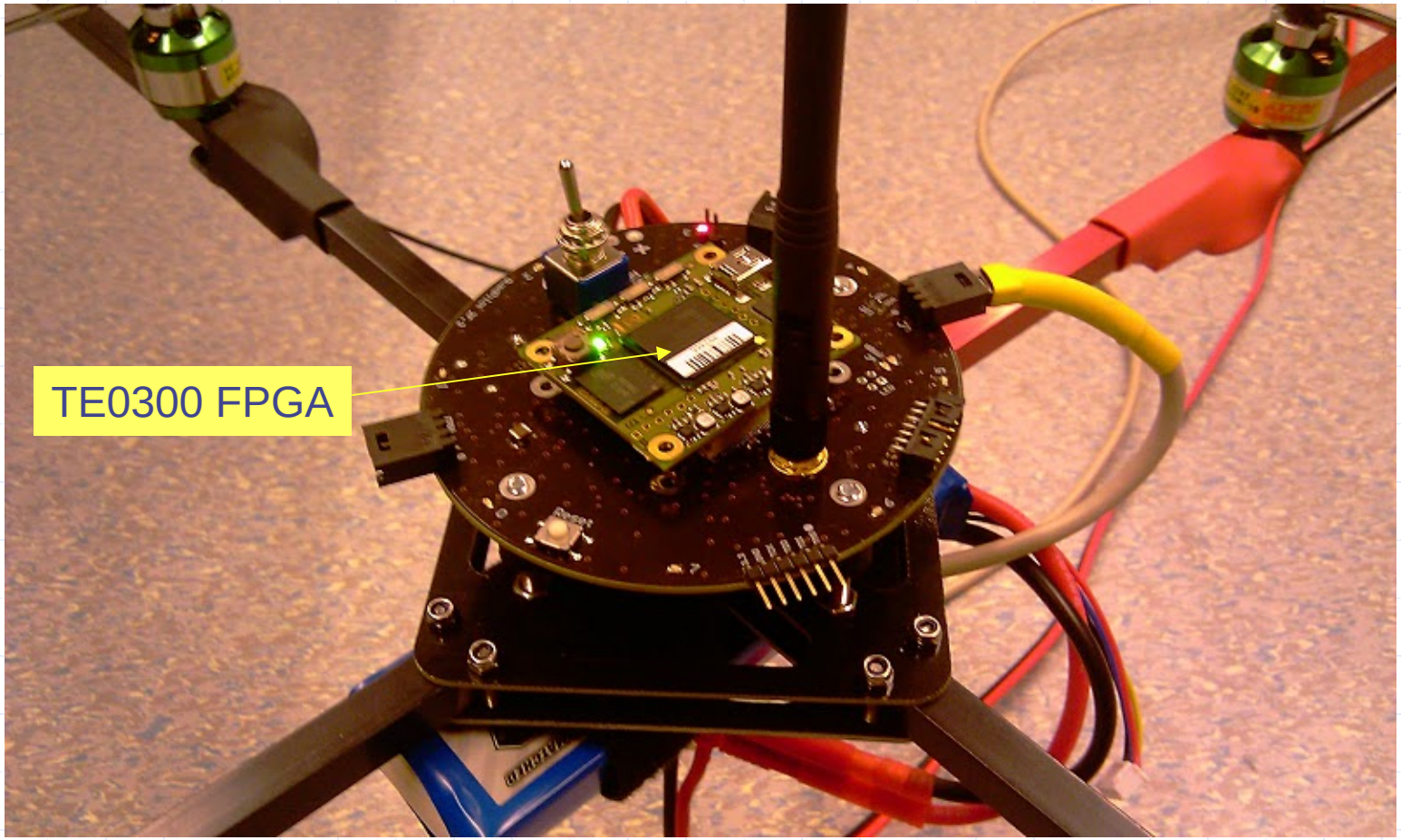
FPGA Board: TE0300



QR: AeroVinci (Aerospace Dept.)



QR Interface Electronics



Lab Assignment

- **`assignment.pdf`** on in4073 web site
- Teams (via in4073 lab reg) shown in the break
- Read assignment carefully
- Team KO meeting at lab (lab session 1)
- Start system design ASAP!
- Final demo during final lab session 7
- Submit report at Sun April 8 23:59 CET
- 10 pp. pdf file -> a.j.c.vangemund@tudelft.nl)
- Late submissions (> Sun) are NOT graded
- Reports > 10 pp. are NOT graded

Lab Resources

- Personal login account
- 5 QRs (shared by all teams)
- Per team:
  - 4 (Linux) PCs
  - 2-3 FPGA cards (borrow @ 150 eur deposit)
  - Basic software tools
  - Additional PCs in other rooms
- In4073 Resource Web Page

Study Attitude

- Course load ~ 4 x lab + lecture hours!
- It's a Design Project, no cookbook lab
- Maintain a Log (for your report, for us)
- Deputies Rule (in my absence)
- Meet your deadlines, make an effort
- Resource page has ***all*** the info you need
- Attending lectures proves to be vital
- Lab Absence / Fraude => Disqualification
- Approx. 10-15% drops out

LIFT-OFF!

http://www.youtube.com/watch?v=5XOcbfcTqPU

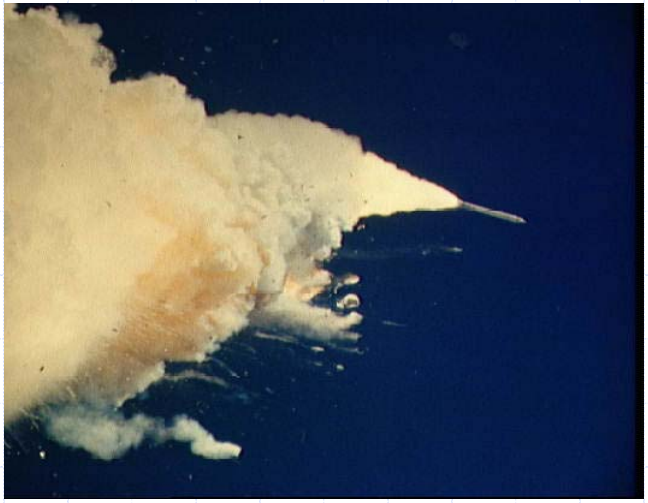
Lab Kick-Off

- Read Assignment Before Next Lecture
- Study in4073 Resource Web Page Before KO
- Study/program PC – joystick SW
- Study/program X32 soft core
- Study/program RS232 communication
- Start software architecture design ASAP

- Lab registration issues: Andreas Loukas (loukasan@gmail.com)

Remember

Expect a lot of challenges!



Make an Effort, Learn, and have Fun!