

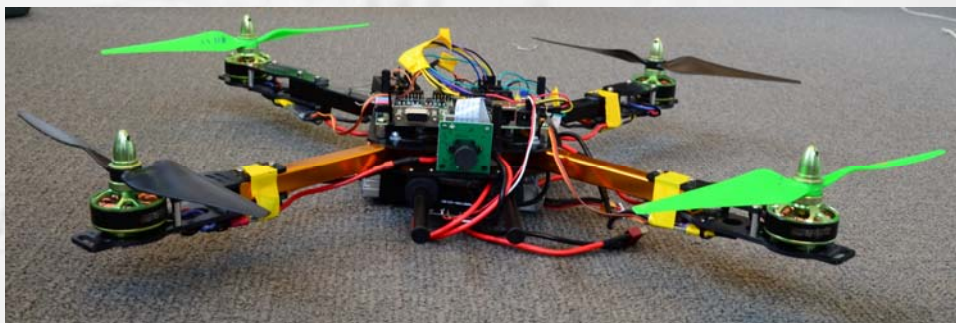
H01q6 Probleem oplossen en ontwerpen Eagle - Inleiding

W. Dehaene, P. Patrinos, S. Pollin, V. Rijmen,
R. Sabariego, T. Tuytelaers, M. Verhelst, P. Wambacq



Meet... EAGLE!

ESAT's Autonomously Guided Lightweight Educational Drone
(or whatever other acronym you like with these letters...)



ESAT's new P&O (Problem Solving and Design)

- ❑ What are we going to make? ←
- ❑ How to handle a large design
- ❑ How to apply this in EAGLE
- ❑ Practical arrangements
- ❑ Conclusion

Drones are everywhere...



**But none of them are
actually smart or
autonomous...**

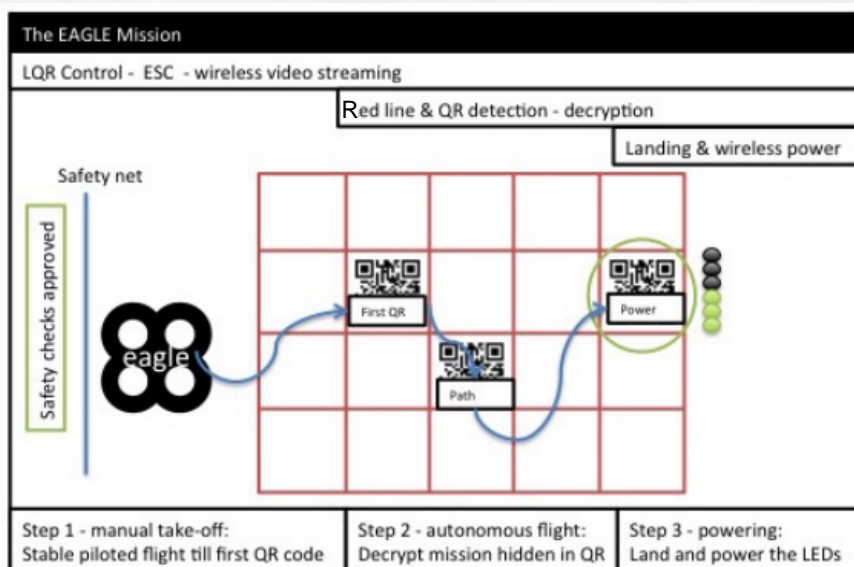
EAGLE design task

- The design task in a nutshell:
 - Design an autonomous drone
 - Which can execute a mission towards powering a remote LED wall
 - With a team of ca. 10 students

!! Big (with a capital 'B') challenge

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Eagle's mission



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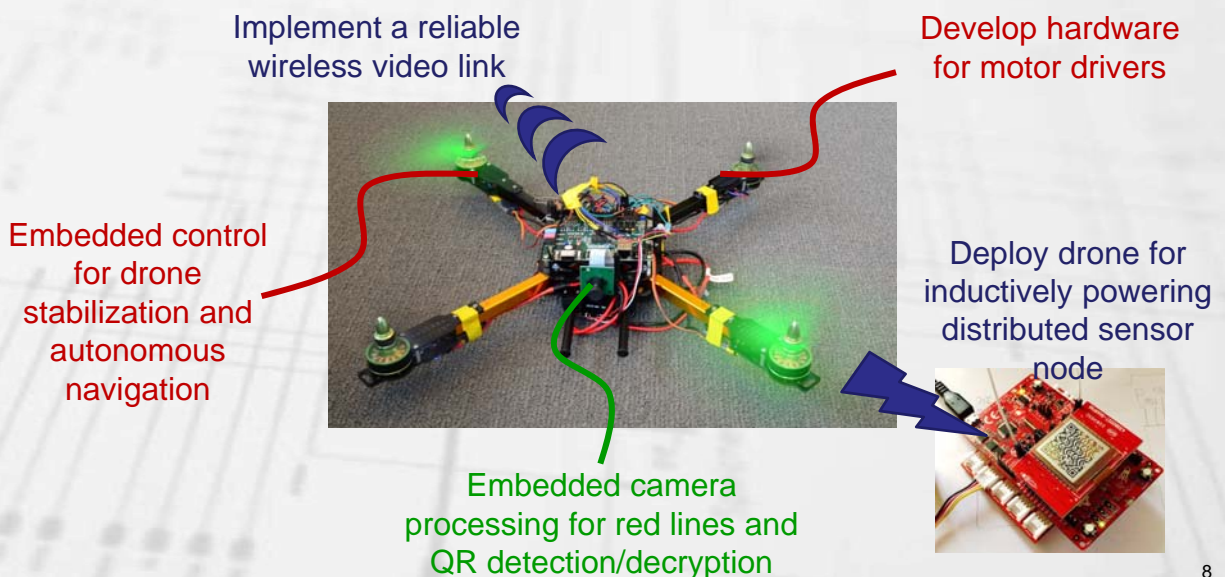
Full design tasks

- ❑ Drone should be able to fly remote controlled, with **good stability and with your own motor drivers**
- ❑ Drone should be able to **autonomously follow a trail** of QR codes in red line grid
- ❑ Drone should be able to **decode its own QR codes**
- ❑ Drone should have a **reliable wireless video link**
- ❑ Drone should be able to **inductively power a LED wall**

→ See introduction document (Toledo) for details

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Eagle challenges



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What you will get (I)

Propellers
2x CW
2x CCW



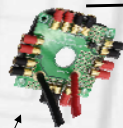
4x engine

Hobbyking
X650F

9

What you will get (II)

PWM
signal
from
ZyBo

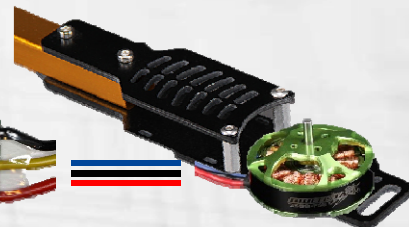


Power
distribution



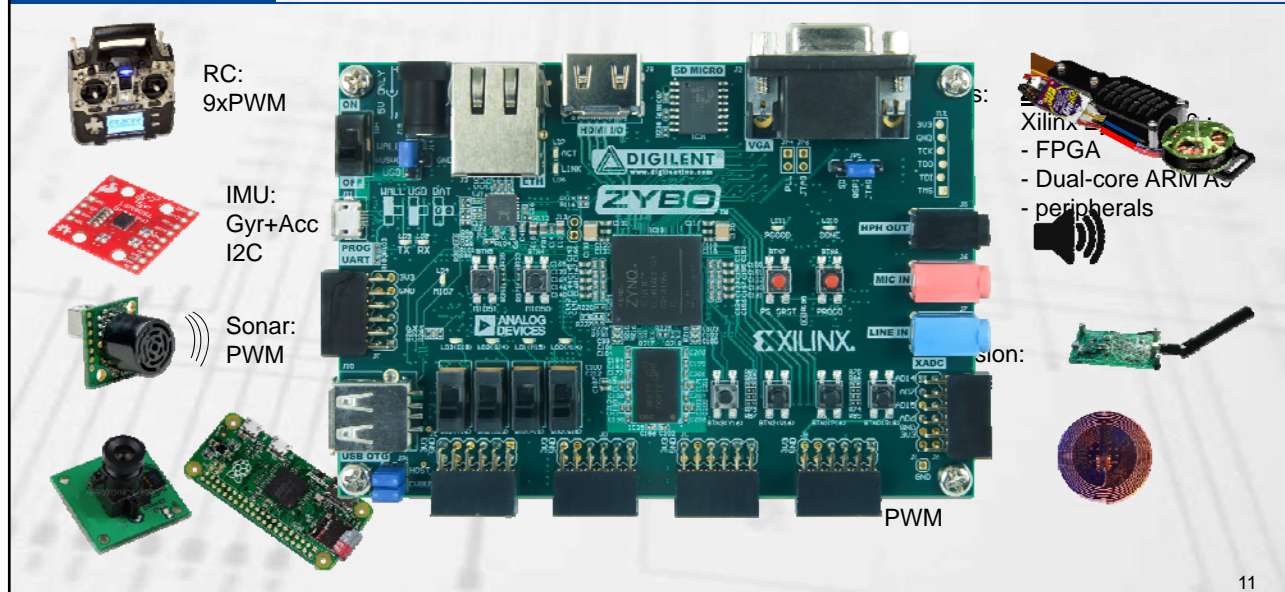
4xESC

LiPo battery



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What you will get (III)



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Outline

- ❑ What are we going to make?
- ❑ **How to handle a large design** ←
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- ❑ Conclusion

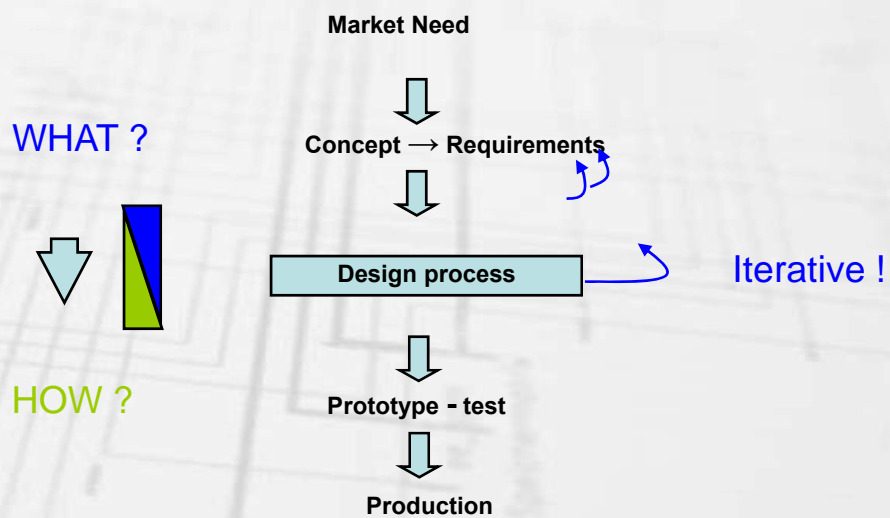
12

Key concepts

- Hierarchy and abstraction
- Divide and conquer
- Incremental design
- Clear communication

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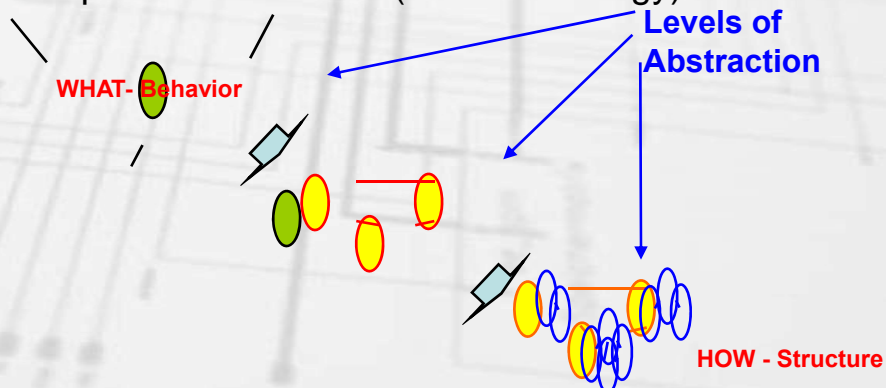
Design Scenario



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Hierarchical decomposition

- Hierarchical composition of the problem
 - From “what” to “how”
 - At each level of abstraction there are known primitive elements (=the technology)



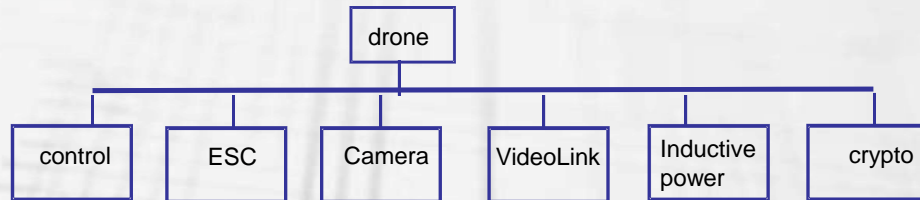
15

Naive example: design of a Kitchen

- First step in design: make a high level plan
 - Where do we cook, do the dishes, cut vegetables, ...
 - Primitive elements: drawers, cupboards, refrigerators, stove, ..
- Next level of abstraction: how to make a cupboard
 - Primitive elements: wood, screws, hinges, ...
- And another level down
 - Primitive elements: trees, iron ore, poly-ethylene, ...

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Functional decomposition of our drone



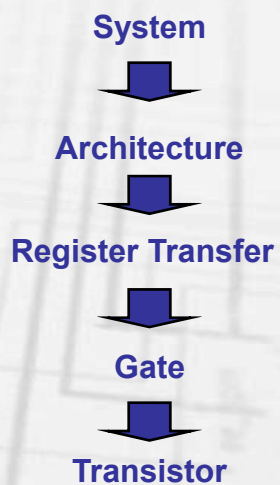
Only rough functional decomposition.
You plan the details yourself

Can serve as a first team split

WARNING: This is not a block diagram !

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Abstraction levels used in Electronic design



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- ❑ At each level we used different models
 - Algorithms in matlab
 - architecture: matlab or C or dedicated languages
 - Gate level: VHDL, Verilog, schematics
 - ...
- ❑ Model is a
 - Validation of the (sub)system at a given level of abstraction
 - Specification and reference for the next level
- ❑ Quality of the model depends on the designer not on the tool
WARNING: GIGO! Garbage in, Garbage out

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- ❑ Model can be on paper or it can be an executable program
- ❑ Executable model is better Virtual prototype
 - Early check of results (Early feedback)
 - High level models are cheaper than low level models.
 - Stimuli / Reference results can be reused/adapted over different levels
 - Simulation results between different levels can be compared
 - ...

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Why is abstraction so important?

- ❑ An engineer cannot solve all problems at the same time!
- ❑ Abstraction levels allow for a step wise approach
- ❑ Allows teamwork and specialization.

- ❑ First comes behavior : “What do we want the thing to do?”
Next comes structure “How are we going to fix this?”

- ❑ The engineer should not have to think about the design of the components when conceiving the system. (and vice versa)

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Problemen met abstractie

- ❑ Communicatie en misverstanden tussen de niveaus zijn mogelijk – gebruik formele vormen van communicatie:
 - formele specificaties
 - samen-simuleren van verschillende abstractieniveaus
 - formele verificatie, i.e. mathematisch aantonen dat simulaties op verschillende niveaus gelijk zijn.

- ❑ Bij slecht gekozen abstracties, m.a.w. men heeft abstractie gemaakt van iets dat op een bepaald niveau dat wel degelijk van belang is, wordt het probleem erger i.p.v. eenvoudiger.

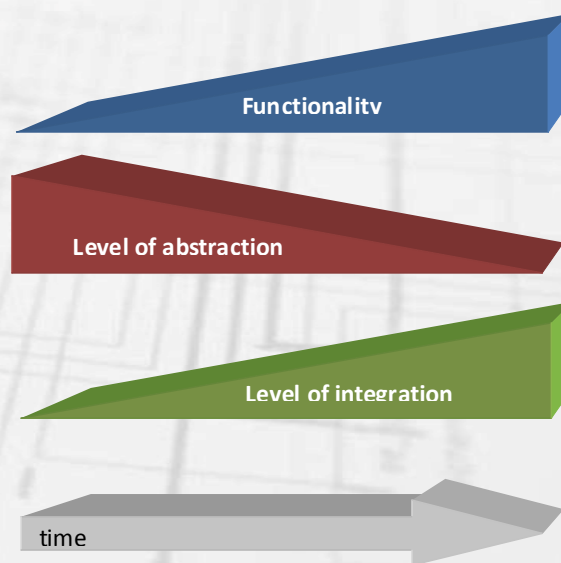
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Divide and conquer

- In different ways
 - Functional decomposition
 - Team split
 - Go from very abstract to concrete, complete design

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Split in time Design evolution



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Concurrent engineering

- ❑ We cannot do all tasks sequentially:
 - Lasts too long
 - Is too expensive
- ❑ Sub teams operate in parallel
 - Good agreement on tasks and responsibilities required upfront
 - Good and formal communication required
 - Follow-up by project leaders mandatory

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Clear specifications

- ❑ It is extremely important to document your modules
 - Executable model for internal behaviour
 - Spec documents for interface
- ❑ It always goes wrong in the interfaces

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Good common design practice

- ❑ **Incremental design**: expand the design step by step and verify each step separately.
- ❑ **KISS principe**: “Keep It Simple and Stupid”. The simpler the solution the easier it is to implement, verify, validate, ...
- ❑ **Reuse of “Intellectual Property”**: reuse of existing components and subsystems (HW and SW) is a good idea.
Avoid the “Non-invented-here” syndrome.

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Outline

- ❑ What are we going to make?
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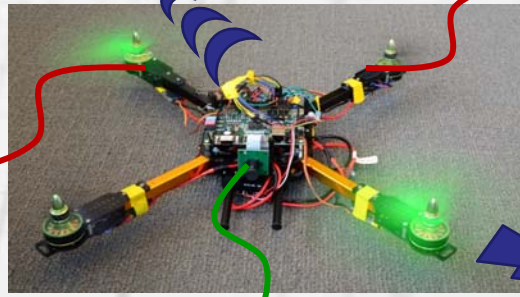
Eagle organization: teams

- 6 tasks, each with step-by-step challenges (see *Task docs Toledo!*)

Implement a reliable
wireless video link

Develop
hardware for
motor drivers

Embedded
control for drone
stabilization and
autonomous
navigation



Embedded camera processing
for red lines and QR
detection/decryption

Deploy drone for
inductively powering
distributed sensor



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Eagle organization: teams

- Student teams
 - 10 students per drone
 - Plan their own tasks / responsibilities

Student team



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Eagle organization: TAs

□ TA's

- Team of 2 coaches + prof per drone team
- 6 technical task experts (one for each task+crypto)

Student team



Team coaches (2 per team + prof)



Task experts

(shared by all 9 drone teams)

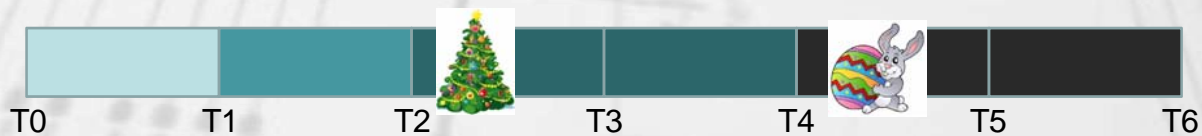


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Eagle organization: Timeline

□ You are free to:

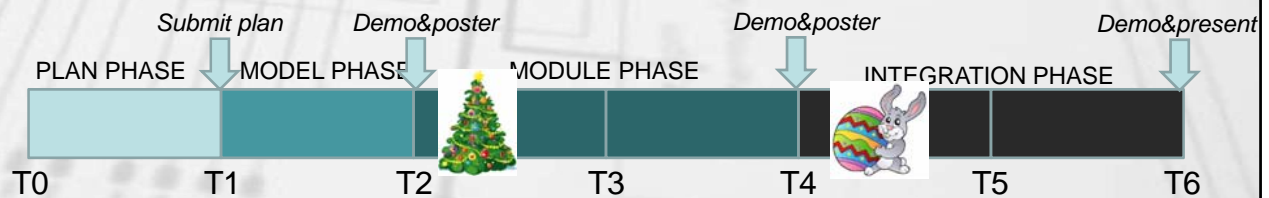
- Organize who works on what
- Plan your own tasks over time
- BUT... we help you
 - By setting milestones / deadlines for every "T-moment"
 - Through close guidance of TA coaches and TA task experts



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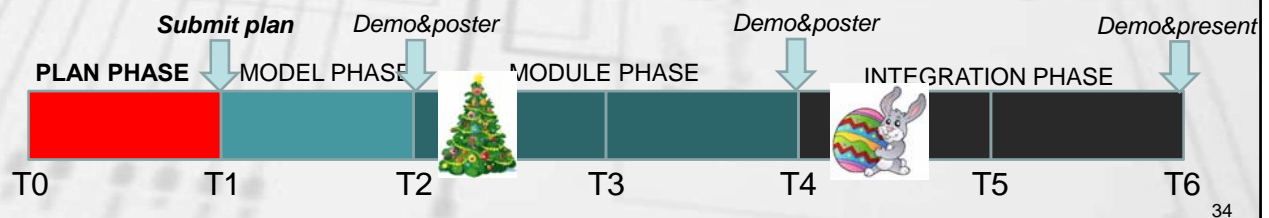
The EAGLE project timeline

- 4 phases
 - T0 → T1: **Plan** phase
 - T1 → T2: **Model** phase
 - T2 → T4: **Module** phase
 - T4 → T6: **Integration** phase
- Concurrent engineering over tasks in all phases!



Phase 1 – Plan phase

- Target
 - Understand your own project and the tasks per module
 - Define tasks and allocate to people
 - Material reading and understand tasks allocated to you
- Deliverable
 - Project plan, task allocation



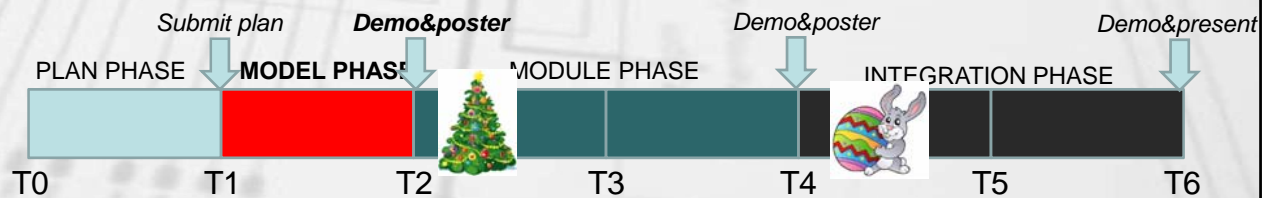
Phase 2 – Model phase

□ Target

- Make a (virtual or physical) models of several sub-blocks
- Create first (simple) proof-of-concept demonstrator

□ Deliverable

- See milestones in EAGLE project description document
- Demo of working prototypes on demo day



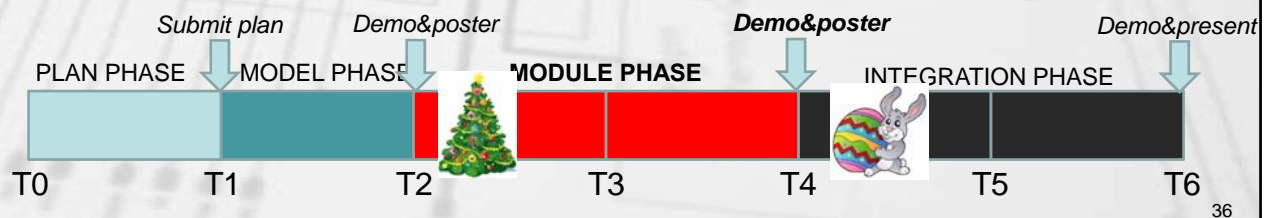
Phase 3 – Module phase

□ Target

- Module design and implementation
- Module test

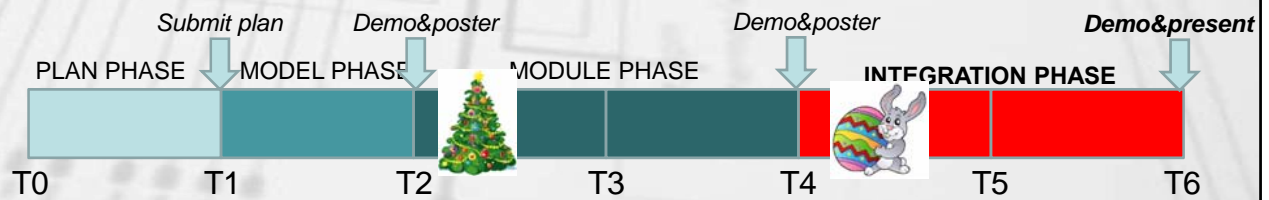
□ Deliverable

- Working modules, demonstrated



Phase 4 – Integration phase

- Target
 - Integrate all modules into a working drone
- Deliverables
 - An autonomous drone!



Phase 5 ?



**The traditional
ESAT
Reception!**

- What are we going to make?
- How to handle a large design
- How to apply this in EAGLE
- **Practical arrangements** ←
- Conclusion

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Toledo... the source of all wisdom!

- You can find EVERYTHING on Toledo
 - All documentation on the project, the subtasks, the software,...
 - The EAGLE calendar: planning, session location, etc.
 - The responsible TA's for your team
 - Task expert Q&A blogs
 - Shared space for your drone team
 - Blog and (self-)evaluation

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Project documentation

- Project description with all target milestones at system level
- 6 task description documents, with:
 - Detailed task explanation
 - All milestones at task level (incl target demo's)
 - Link to all task-relevant documents
- Software and hardware manuals

The screenshot displays a web interface for 'Course information' with a dropdown menu showing 'Toledopedia'. Below this, there are three expandable folders, each with a red folder icon:

- General information**: This folder contains all texts that are useful for the students, eg. the general project description.
- Introduction sessions**: This folder contains the texts about the introduction sessions.
- Module information**: This folder contains information about these modules:
 - Attitude & navigation control
 - Electronic speed control (ESC)
 - Image processing
 - Cryptography
 - Wireless video link
 - Wireless power transfer

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Day	Date	Begin	End	What and who	Where (ordered as in the previous columns)
Monday	26.09.16	13:30	16:00	Academic year opening	
Monday	26.09.16	16:00	18:30	Academic year opening	
Tuesday	27.09.16	16:00	18:30		
Monday	03.10.16	13:30	16:00	Introduction, all groups	T1.01.02, 00.57, 01.60, B91.100, B91.200
Monday	03.10.16	16:00	18:30	Brainstorm taakverdeling + planning	00.57, 01.60, B91.100, B91.200
				00.57: teams E1-E3 and modules ESC, wireless power transfer	
				01.60: teams E4-E5 and modules image processing, cryptography	
				B91.100: teams E6-E7 and module attitude & navigation control	
				B19.200: teams E8-E9 and module wireless video link	
Tuesday	04.10.16	16:00	18:30		
Monday	10.10.16	13:30	16:00	start-up meeting with coach (start on actual tasks)	00.60, 02.53, 02.54, 00.62
Monday	10.10.16	16:00	18:30	worksession1.1; optional: crypto details in B91/100, LQR in B91.200	00.60, 02.53, 02.54, B91.200, B91.300, 00.62
				00.62: teams E1-E3 and modules ESC, wireless power transfer	
				02.53: teams E4-E5 and modules image processing, cryptography	
				02.54: teams E6-E7 and module attitude & navigation control	
				00.60: teams E8-E9 and module wireless video link	
Tuesday	11.10.16	16:00	18:30		
Monday	17.10.16	13:30	16:00	E1-E3: test&measurement in 02.58; E4-E9: worksession2.1	01.57, 02.53, 02.54, 02.58, 00.62
Monday	17.10.16	16:00	18:30	E1-E3: w2.1; E4-E6: test & measurement in 02.58; E7-E9: w2.2	01.57, 02.53, 02.54, 02.58, 00.62
				for this day and all next Mondays in the first semester:	
				00.62: teams E1-E3 and modules ESC, wireless power transfer	
				02.53: teams E4-E5 and modules image processing, cryptography	
				02.54: teams E6-E7 and module attitude & navigation control	
				01.57: teams E8-E9 and module wireless video link	
Tuesday	18.10.16	16:00	18:30		
Monday	24.10.16	13:30	16:00	E1-E6: w2.2; E7-E9: test&measurement in 02.58	01.57, 02.53, 02.54, 02.58, 00.62
Monday	24.10.16	16:00	18:30	worksession3.1	01.57, 02.53, 02.54, 02.58, 00.62
Tuesday	25.10.16	16:00	18:30		
Monday	31.10.16	13:30	16:00	worksession4.1	01.57, 02.53, 02.54, 00.62
Monday	31.10.16	16:00	18:30	worksession4.2	01.57, 02.53, 02.54, 00.62

On Toledo!



▼ P&O Elektrotechniek EAGLE

- Announcements
- Course information
- Who does what?
- Email
- Groups
- File sharing
- Schedule**
- Beoordeling 1e sem ☑
- Bedrijfsbezoeken ☑
- Peer/Group Assessment ☑
- ECTS

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The EAGLE calendar (I)

- See Toledo for dates, rooms, planned sessions,...

teams	EAGLE1, EAGLE2, EAGLE3	EAGLE4, EAGLE5	EAGLE6, EAGLE7	EAGLE8, EAGLE9
Oct. 3	91.B100	01.60	00.57	91.B200

□ PLAN PHASE:

- Sit with your team to read upon tasks, plan, ... and start the action!

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The EAGLE calendar (I)

- See Toledo for dates, rooms, planned sessions,...

teams	EAGLE1, EAGLE2, EAGLE3	EAGLE4, EAGLE5	EAGLE6, EAGLE7	EAGLE8, EAGLE9
modules	ESC, wireless power transfer	Image processing cryptography	Attitude & navigation control	Wireless video link
Oct. 10	00.62	02.53	02.54	00.60
	cryptography (91.B100), LQR control (91.B200)			
Oct. 17 onwards	00.62	02.53	02.54	01.57
	test- and measurement session (02.58)			

□ PLAN PHASE:

- Sit with your team to read upon tasks, plan, ... and start the action!
- Scheduled test- and measurement session (17&24.10, mandatory) and task lectures (10.10, optional) → dates & location: Announced on Toledo

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The EAGLE calendar (II)

- See Toledo for dates, rooms, planned sessions,...

teams	EAGLE1, EAGLE2, EAGLE3	EAGLE4, EAGLE5	EAGLE6, EAGLE7	EAGLE8, EAGLE9
modules	ESC, wireless power transfer	Image processing cryptography	Attitude & navigation control	Wireless video link
Oct. 17 onwards	00.62	02.53	02.54	01.57

- **MODEL PHASE:**
 - Work on your tasks
 - Find room allocations for groups and tasks on Toledo doc
 - Ends with demo & poster session

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Demo & poster session

- After phase 2 (models) and phase 3 (modules)
- Each drone team makes
 - Up to 3 posters about their work
 - A demo of working components
 - Can be SW or HW demo
 - According to milestones given in task documents

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The EAGLE calendar (III)

- See Toledo for dates, rooms, planned sessions,...

- MODULE PHASE:
 - Work on your tasks + start to integrate parts
 - Find room allocations for groups and tasks on Toledo doc
 - Ends with demo & poster session

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The EAGLE calendar (IV)

- See Toledo for dates, rooms, planned sessions,...

- MODULE PHASE:
 - Integrate parts
 - Room allocations will be given on Toledo
 - Ends with demo & presentation session

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The calendar (V)

- Your presence is required on **_EVERY_** session.
Exceptions can only be granted by me.

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Dragon guidance

- Each team will have 2 TA coaches who will guide you through the project. The first stop in case you have problems

Groups	TA coach	TA coach	Prof coach
EAGLE1	Fernando de la Hucha Arce	Jasper Wouters	Alexander Bertrand
EAGLE2	Sander Smets	Tom Molderez	Marian Verhelst
EAGLE3	Victor Arribas Abril	Tariq Elahi	Vincent Rijmen
EAGLE4	Pieter Maene	Danilo Sijacic	Patrick Wambacq
EAGLE5	Jolien Demeester	Robin Theunis	Wim Dehaene
EAGLE6	Punarjay Chakravarty / B. Wei	Pantelis Sopasakis	Panos Patrinos
EAGLE7	Mojtaba Chehelcheraghi	Alessandro Chiumento	Sofie Pollin
EAGLE8	Boyuan Wei	Mudar Abedrabbo	Ruth Sabariego
EAGLE9	Klaas Kelchtermans	Tom Roussel	Tinne Tuytelaars

- You agree with your coaches when you will meet, and how you interface/communicate

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Task experts



- ❑ Every task has a task expert to help where the team coaches can't help
- ❑ Questions to task experts are always posted on Toledo in the task blog
- ❑ Everyone can see the question and answers

Q&A: Attitude & navigation control	Course	9/20/16 11:13 AM	0
Q&A: Cryptography	Course	9/20/16 11:15 AM	0
Q&A: Electronic speed control (ESC)	Course	9/20/16 11:14 AM	0
Q&A: Image processing	Course	9/20/16 11:15 AM	0
Q&A: Wireless power transfer	Course	9/20/16 11:17 AM	0
Q&A: Wireless video link	Course	9/20/16 11:16 AM	0

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Task expert list

Groups	Expert
Image processing	Tom Roussel
Control	Pantelis Sopasakis
Crypto	Tomer Ashur
ESCs	Roel Uytterhoeven
Wireless link	Yuri Murillo
Inductive powering	Hamada Almasalma

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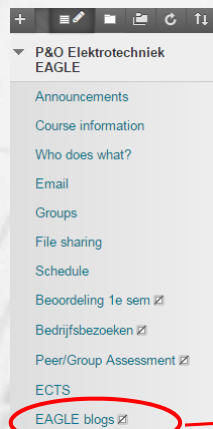
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Group space on Toledo

- ❑ You are all in your drone's Toledo group
- ❑ The group shares a blog & file exchange space
 - File exchange: My groups > File exchange
- ❑ You can only see from your own group!



<input type="checkbox"/>	Name	Type	Last Modified Date	Entries
<input type="checkbox"/>	EAGLE 1	Group	9/15/16 8:56 AM	0
<input type="checkbox"/>	EAGLE 2	Group	9/15/16 8:56 AM	0
<input type="checkbox"/>	EAGLE 3	Group	9/15/16 8:56 AM	0
<input type="checkbox"/>	EAGLE 4	Group	9/15/16 8:56 AM	0
<input type="checkbox"/>	EAGLE 5	Group	9/15/16 8:56 AM	0

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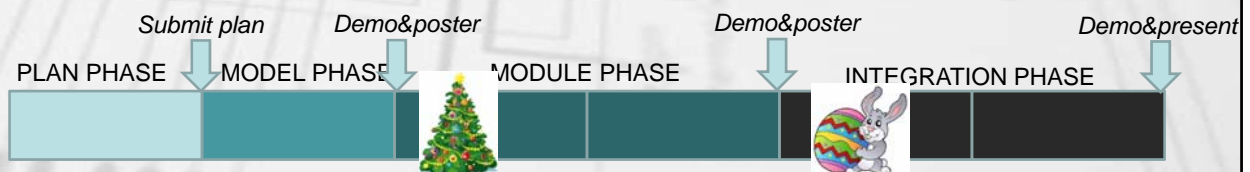
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Exams and points

- EAGLE is a course, which we have to grade.
- Mix of hard skills, and soft skills:

Table 1: Milestones

Deadline	Milestone
T1	- Project Gantt chart + person allocations
T2	- First set of demos ready - Electronic Speed Control module: Open loop breadboard design done - Wireless Link module: Video streaming finished - Image Processing module: Red line detection finished - Wireless Transfer module: Design finished and first prototype



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Exams and points

- ❑ EAGLE is a course, which we have to grade.
- ❑ Mix of hard skills, and soft skills:
 - Hard skills
 - Technical performance according to milestones (see project description at Toledo)
 - Evaluated at T2 – T4 – T6 (demo sessions)

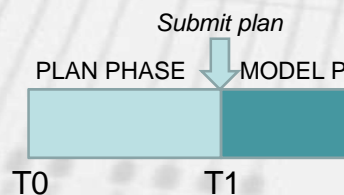


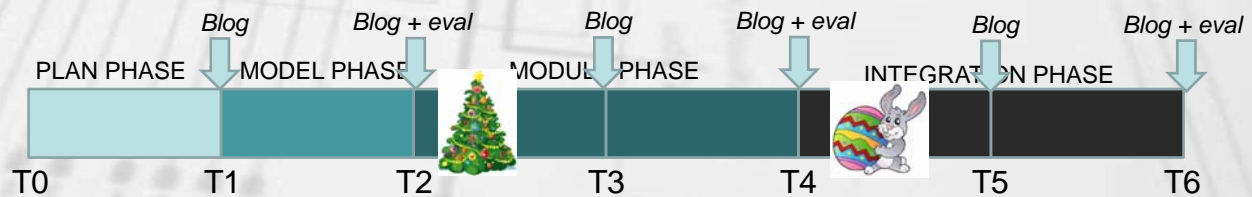
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Exams and points

- ❑ EAGLE is a course, which we have to grade.
- ❑ Mix of hard skills, and soft skills:
 - Soft skills:
 - Personal motivation, team functioning, reporting, collaboration, constructive discussion,...
 - Permanent evaluation by your coaches (and professors) at T1 – T2 – T3 – T4 – T5 – T6
 - Blog and self- / peer evaluation on Toledo



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EAGLE blog?

- ❑ Every team has private blog
- ❑ At every T-moment in the project, short blog about:
 1. on your achieved progress according to your own plan and the given milestones
 2. on what problems you encountered
 3. on whether the plan has to be modified and why
 4. on the consequences of these modifications (updated plan)
- ❑ Complementary self-evaluation in Toledo at T2 – T4 – T6
- ❑ All deliverable through Toledo
- ❑ Deadlines are HARD deadlines

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EAGLE evaluation

Table 2: Time frame and weights of the evaluations

Timeframe	To deliver	To be evaluated	Percentage of soft skills	Percentage of hard skills
T1	Blog	Planning Teamwork	0%	/
T2	Blog	Adjustment of planning Teamwork	17%	22%

Niet teveel mee bezig zijn. Have fun. Doe uw ding. Denk mee na. Zet je in voor team. Wees proactief en creatief. Wees gewoon ingenieur, en dan komt alles goed!

T5	Blog	Adjustment of planning Teamwork	17%	/
T6	Blog Demonstration Self- and peerevaluation	Result Teamwork Milestones	32%	33%

- ❑ All intermediate evaluations will be visible via Toledo. Listen to your coaches. They'll help you to even improve!
- ❑ Final review and responsibility is with professors

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Summary

- ❑ Every “T-moment”:
 - (exact date on Toledo)
 - Has milestones defined ([project document](#))
 - Requires a blog and self-assessment ([Toledo](#))
 - Has a TA evaluation of his/her own team (visible to students) ([Toledo](#))
- ❑ You drive the work, supported by coaches
- ❑ All info on Toledo → Use it. **All other info is invalid**
- ❑ In case of non-technical problems: W. Dehaene

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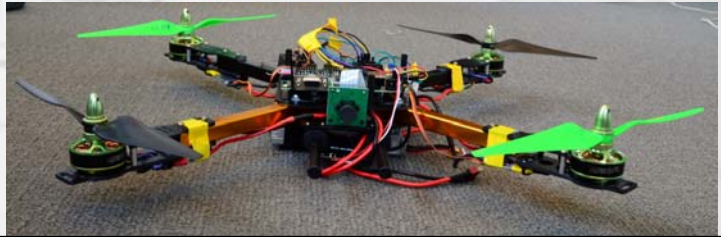
Outline

- ❑ What are we going to make?
- ❑ How to handle a large design
- ❑ How to apply this in EAGLE
- ❑ Practical regulations
- ❑ **Conclusion** ←

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Conclusion

- ❑ You are up to a nice and rewarding challenge!
- ❑ The way this project is organized will require a lot of personal initiative and creativity
- ❑ It is YOUR project! Make something of it!
- ❑ We' re there to help you!



Rest of today and coming weeks?

- ❑ Go meet your coach

teams	EAGLE1, EAGLE2, EAGLE3	EAGLE4, EAGLE5	EAGLE6, EAGLE7	EAGLE8, EAGLE9
Oct. 3	91.B100	01.60	00.57	91.B200

- ❑ Start understanding and planning the tasks
 - Planning excel sheet available... (Toledo > Course information > General information)
- ❑ Get your hands dirty (starts the tasks, no time to waste...)!

Movie



Can you make this drone smarter?