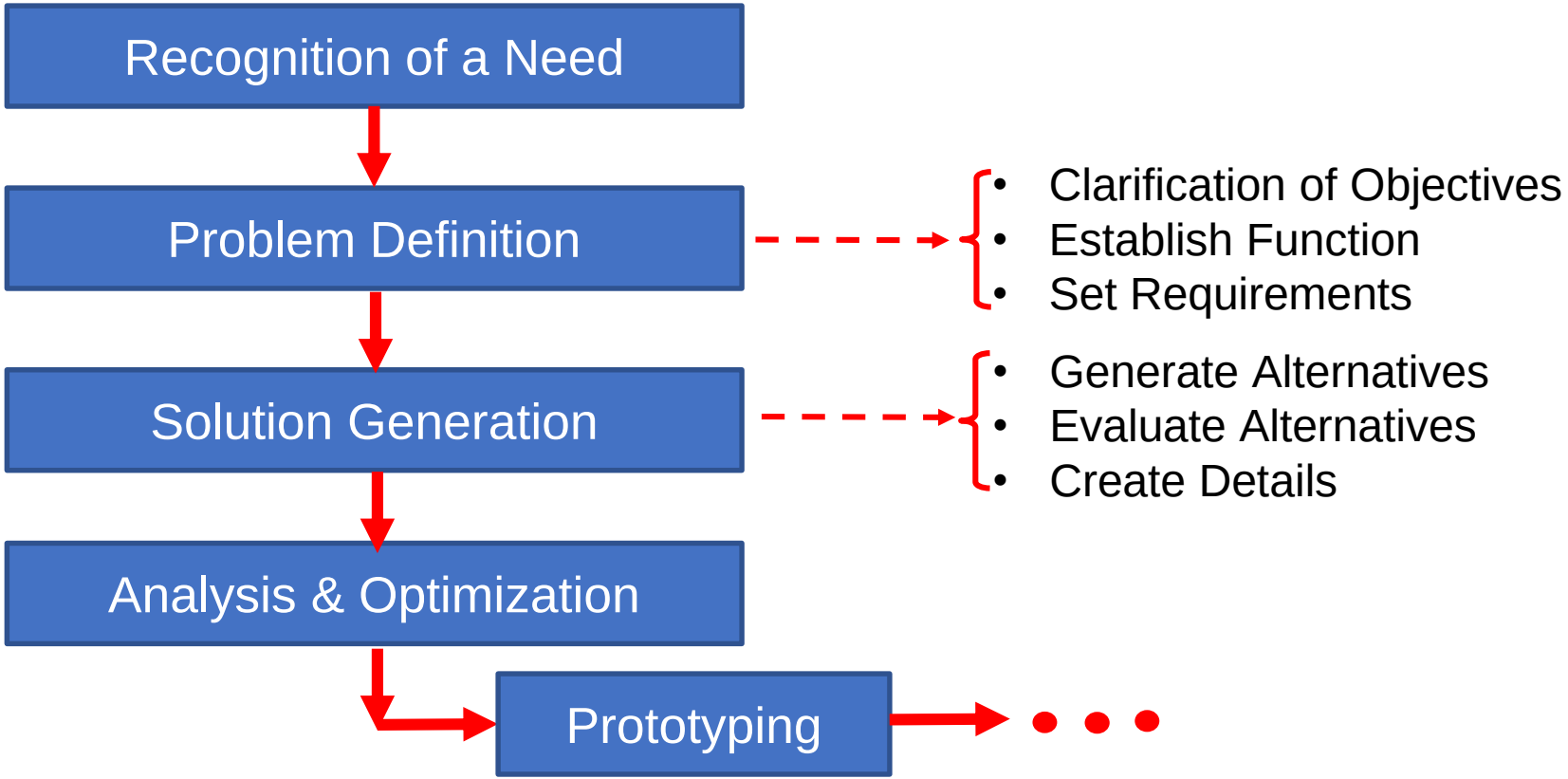
CS/EE/ME 75(a)

Oct. 23, 2019

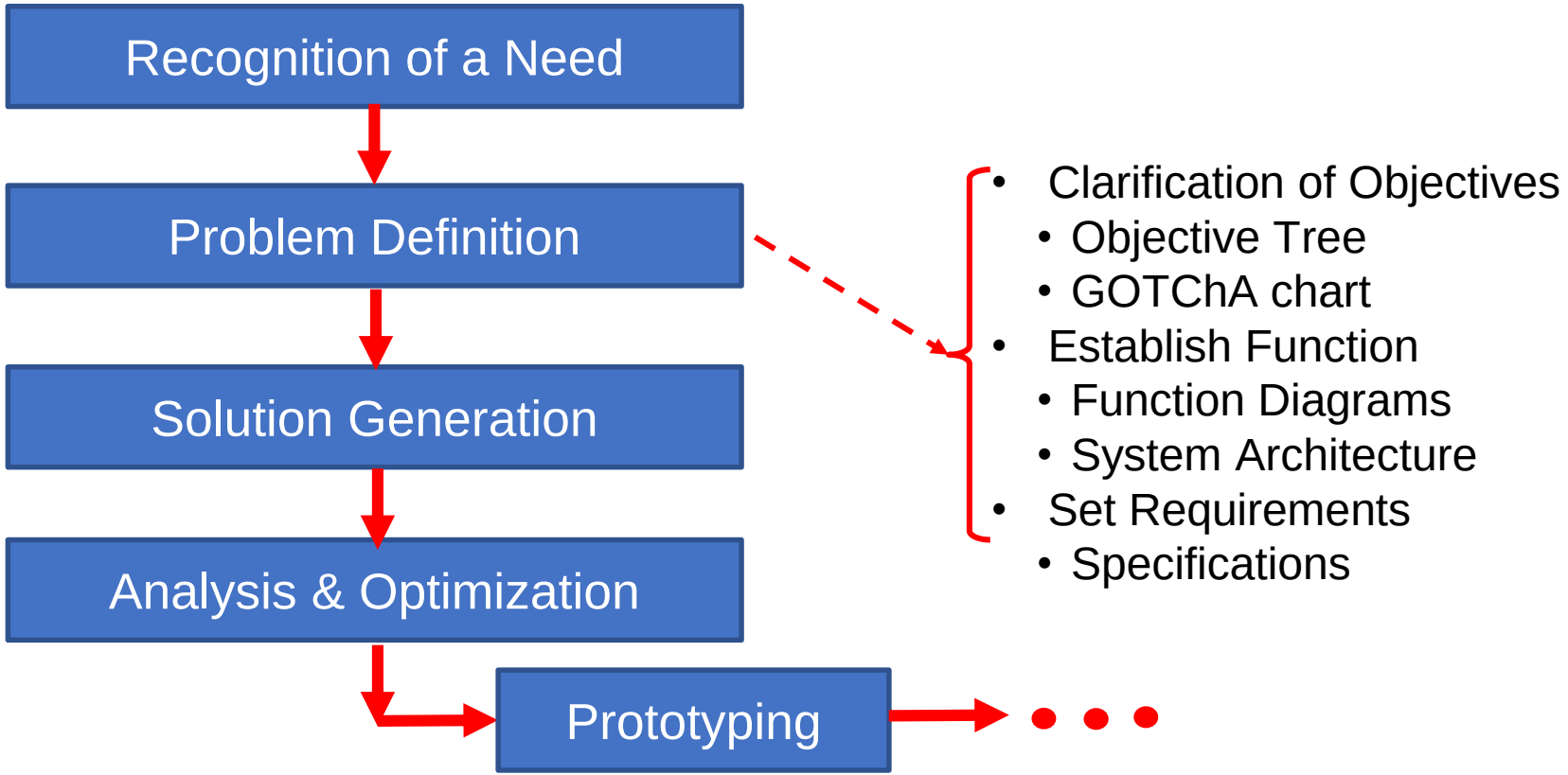
Today:

- Gitlab, Slack, Wiki,
- Group Meeting times
- Requirements/Specifications
- Generate/Evaluate Alternatives
- Homework: projects & general

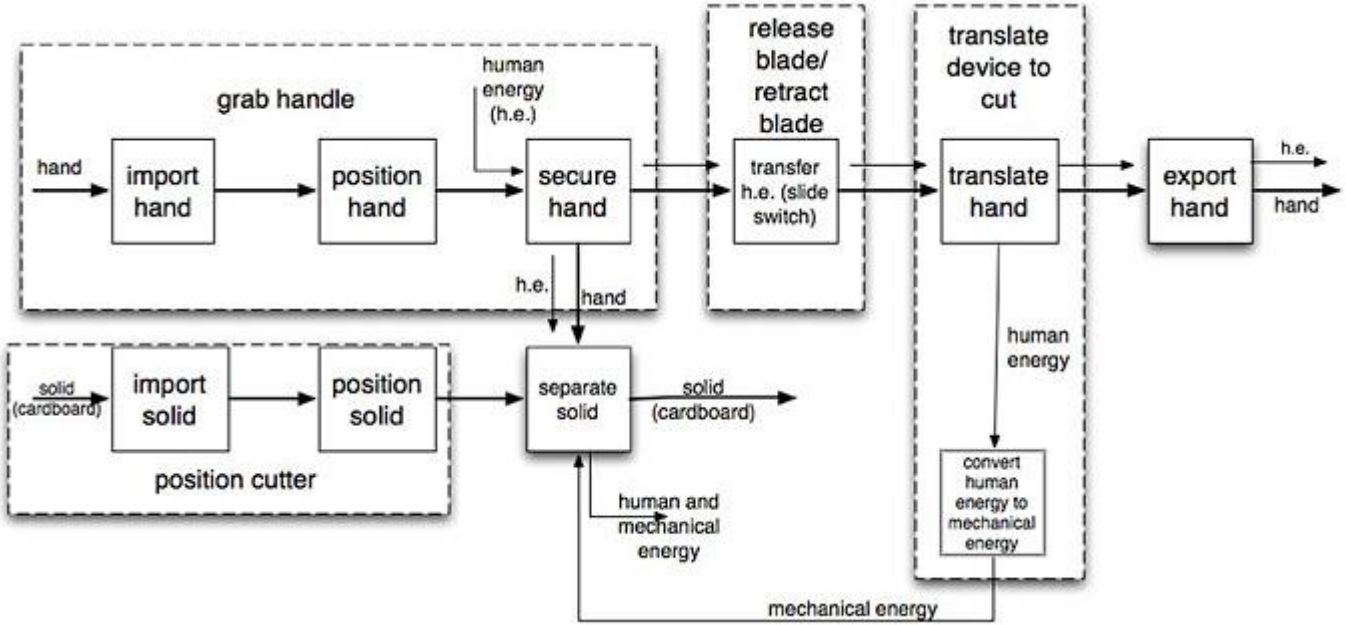
Structured Design Method(s)



Structured Design Method(s)



Function Diagram



System Architecture

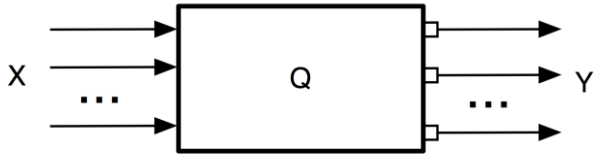
What is an Architecture:

- A model/structure of the system
- Properties of the various elements involved in the system
- Relationships between the various elements
- Behaviors and Dynamics of the various elements
- Multiple Views of the system (from energy usage, information usage

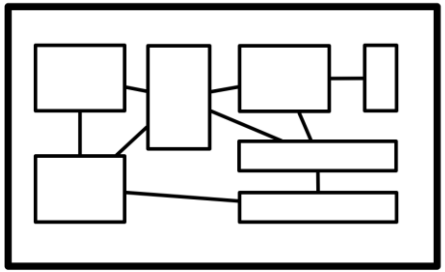
System Architecture

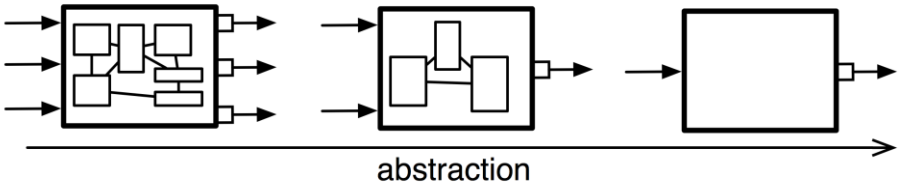
Requirements for an Architecture:

- The objects/elements of the system can be modeled (possibly as their own systems)



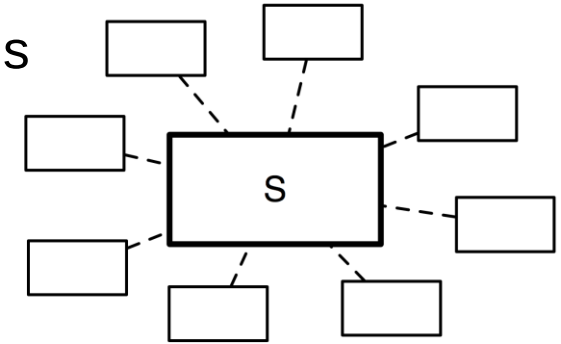
- System can be broken down into small systems (hierarchy)
  - Can be considered at various levels of abstraction



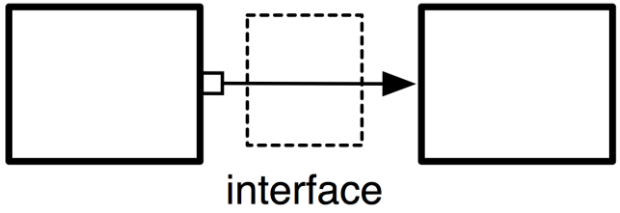


System Architecture

- Interactions with environment and other systems



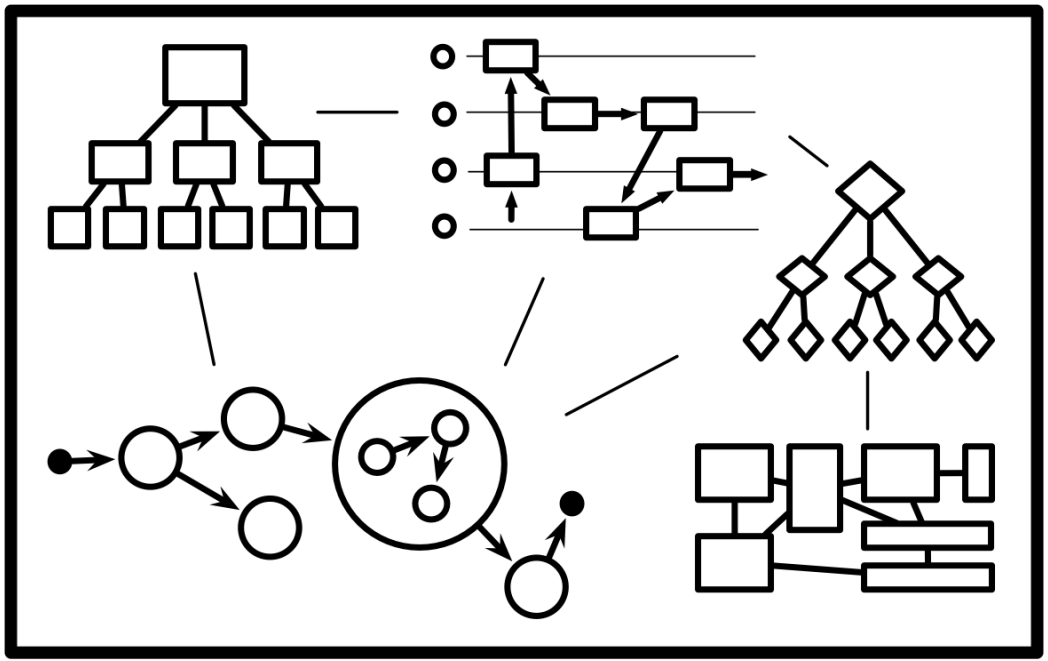
- Interfaces between components



- Socio-Technical Aspects
- Behaviors and Dynamics of the various elements
- Multiple Views of the system (from energy usage, information usage

System Architecture

- Multiple Views of the system (from energy usage, information usage



Specifications/Requirements

- Specification = “to state explicitly, or in detail”
- Describe what component *should be,* not how to build it.
- Common types of specifications:
  - **Functional Performance:** speed, power, energy capacity,
  - **Operating conditions:** temp., humidity, pressure
  - **Physical Attributes:** mass, volume, max dimension
  - **Reliability:** Safety, MTBF
  - **Life-cycle:** maintenance, repair,
  - **Constraints:** cost, time to completion, standards
  - **Manufacturing Issues:** materials, processes, quantity
  - **Human Factors:** complexity of interface, user operation

Specifications/Requirements

Why?

- Communicate between design/development teams.
- Limit frequent system changes and design updates.
- Avoid lack of compatibility in subsystems

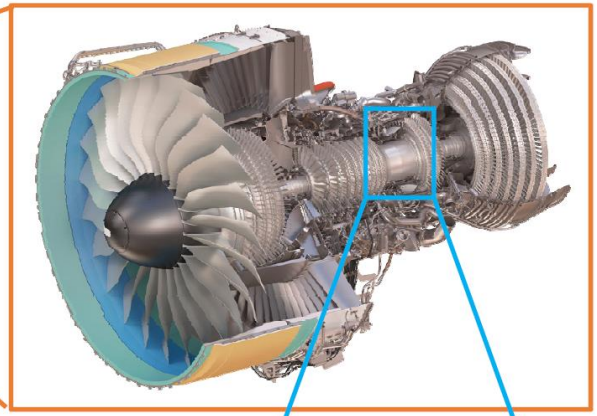
How?

- Identify the *stakeholders* of your design/subsystem
  - Who will use your system?
  - What teams (design, develop, test, field) will be affected by your subsystem?
  - Who will maintain your system?
  - Who else will be affected by your system? (e.g., DARPA clean-up crews)
- ***Requirements:*** that must be satisfied by subsystem
- ***Specifications:*** quantify the limits or performance of your subsystem

Example of Specifications

AIRBUS A380

Engine Alliance
GP 7270



Single
annular
combustor

AIRBUS A380 – Specifications

Specifications set by outside rules

FAA Aircraft Design Group	Aircraft Type	Minimum Wingspan(ft)	Maximum Wingspan(ft)
I	Small Regional	0	49
II	Medium Regional	50	79
III	Narrow body/ Large Regional	80	118
IV	Wide body	119	171
V	Jumbo	172	214
VI	Super Jumbo	215	262

Specifications set by performance

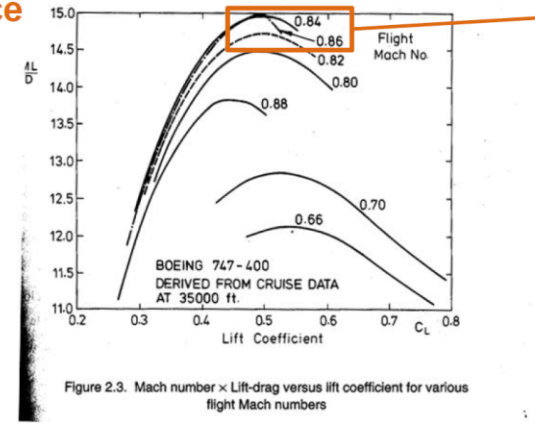


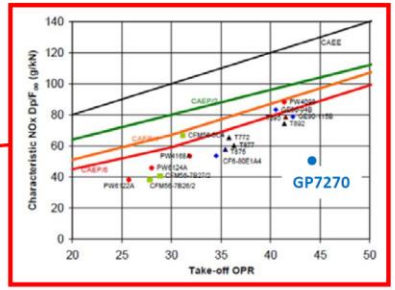
Figure 2.3. Mach number × Lift-drag versus lift coefficient for various flight Mach numbers

Measurement	A380-800
Cockpit crew	Two
Seating capacity	525 (3-class), 644 (2-class), 853 (1-class)
Length	73 m (239 ft 6 in)
Span	79.8 m (261 ft 10 in)
Height	24.1 m (79 ft 1 in)
Wheelbase	30.4 m (99 ft 8 in)
Outside fuselage width	7.14 m (23 ft 6 in)
Cabin width, main deck	6.58 m (21 ft 7 in)
Cabin width, upper deck	5.92 m (19 ft 5 in)
Wing area	845 m² (9,100 sq ft)
Operating empty weight	276,800 kg (610,200 lb)
Maximum take-off weight	560,000 kg (1,235,000 lb)
Cruising speed	Mach 0.85 (1041 km/h, 647 mph, 562 knots)
Maximum cruising speed	Mach 0.89 (1090 km/h, 677 mph, 588 knots)
Maximum speed	Mach 0.96[111] (1176 km/h, 731 mph, 635 knots)
Take off run at MTOW	2,750 m (9,020 ft)[87]
Range at design load	15,200 km (8,200 nmi, 9,400 mi)
Service ceiling	13,115 m (43,000 ft)[112]
Maximum fuel capacity	310,000 L (81,890 US gal, 68,200 imp gal)
Engines (4 x)	GP7270 (A380-861)
Thrust (4 x)	311 kN (70,000 lbf)

GP 7270 – Specifications

Specifications set by other systems

Takeoff Thrust	(SLS, ISA) Flat rated 86F / 30C 70,000 lb/311kN
Cruise Thrust	35,000ft / 10,668m 0.85Mn ISA 12,633lb/56kN
Noise	25.6dB margin to Stage 3
Emissions	Nox 51.6 ~~HC 5.4~~ CO 44.9g/kN
OPR(Max Climb)	43.9
BPR(cruise)	8.7
Thrust Setting Parameter	N1
Length	187in/475cm
Diameter	124in/316cm
Fan Diameter	116.in/296cm
Staging	FAN 1 LPC 5 HPC 9 Single Annular Combustor HPT 2 LPT 6



Specifications better than required

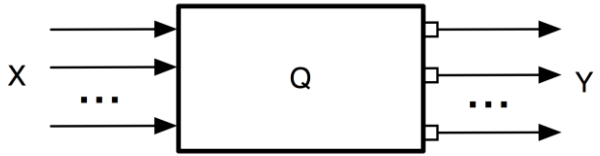
Specifications constrained by other systems

Specifications set by performance

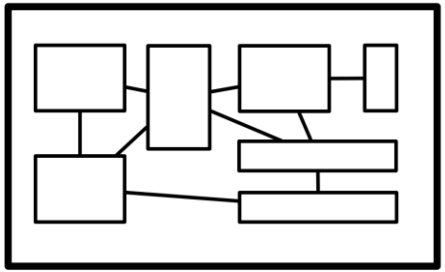
System Architecture

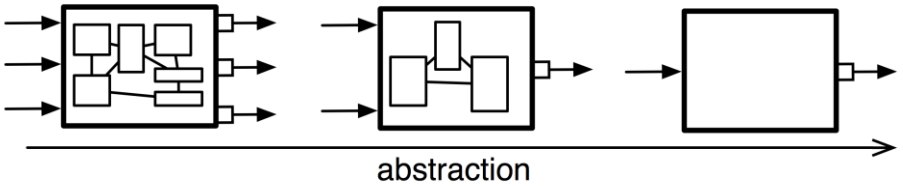
Requirements for an Architecture:

- The objects/elements of the system can be modeled (possibly as their own systems)



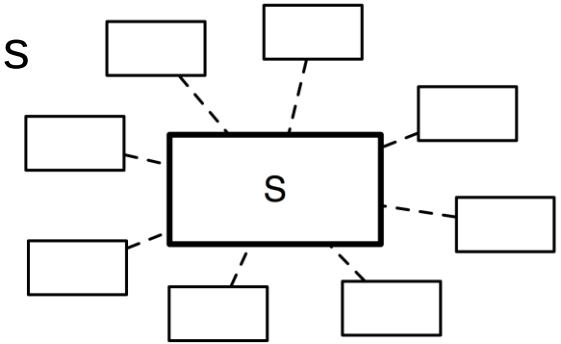
- System can be broken down into small systems (hierarchy)
  - Can be considered at various levels of abstraction



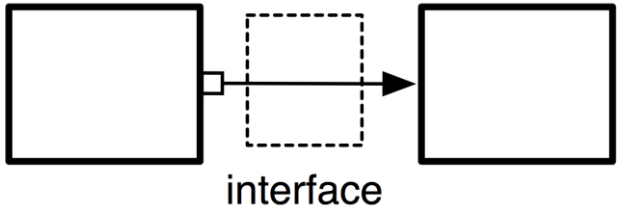


System Architecture

- Interactions with environment and other systems



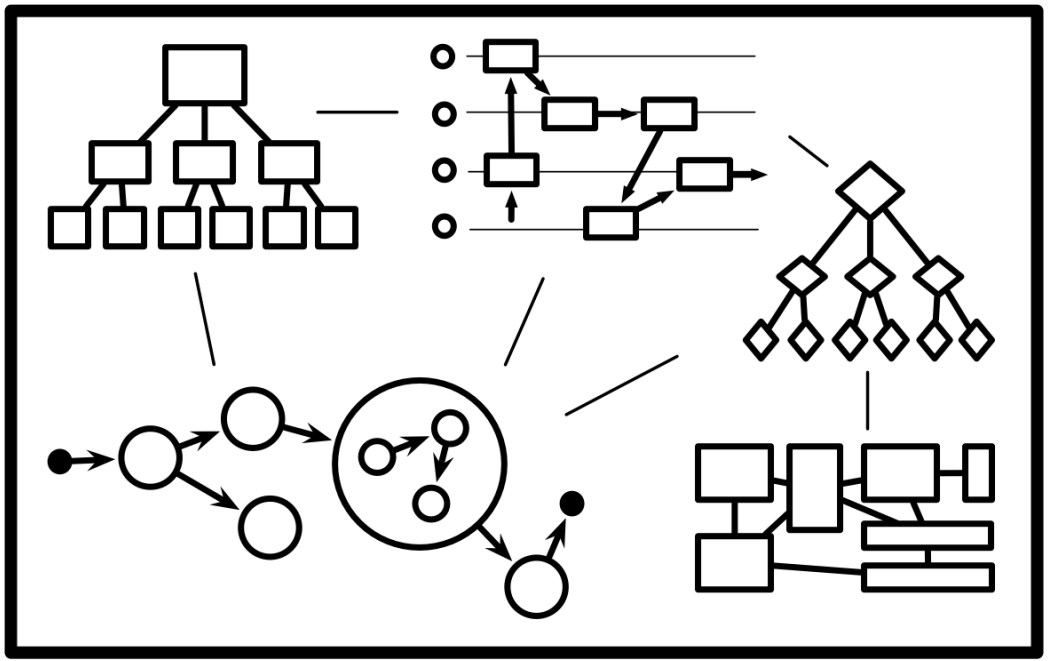
- Interfaces between components



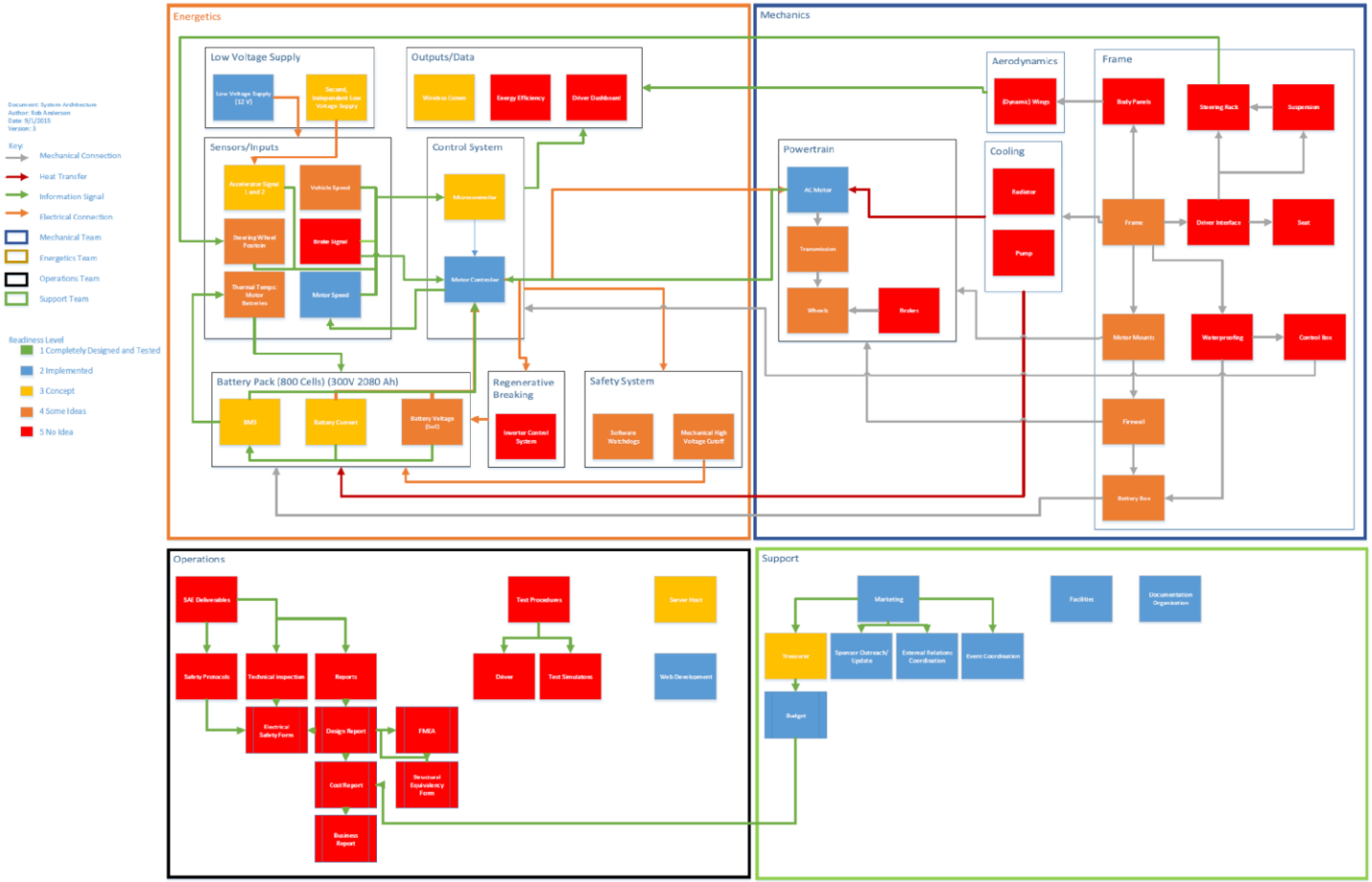
- Socio-Technical Aspects
- Behaviors and Dynamics of the various elements
- Multiple Views of the system (from energy usage, information usage

System Architecture

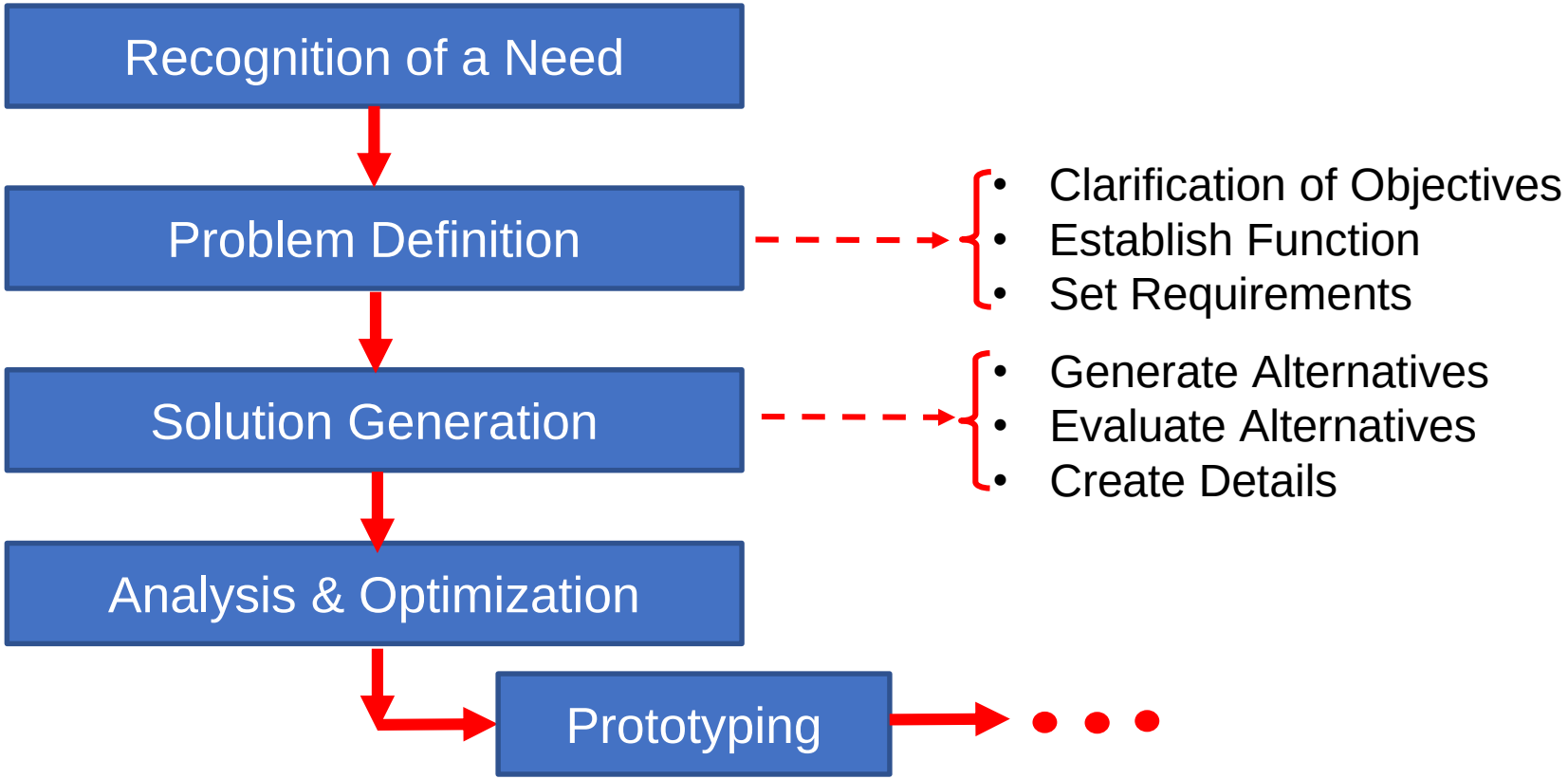
- Multiple Views of the system (from energy usage, information usage



System Architecture & Stakeholders



Structured Design Method(s)



Generate Solutions

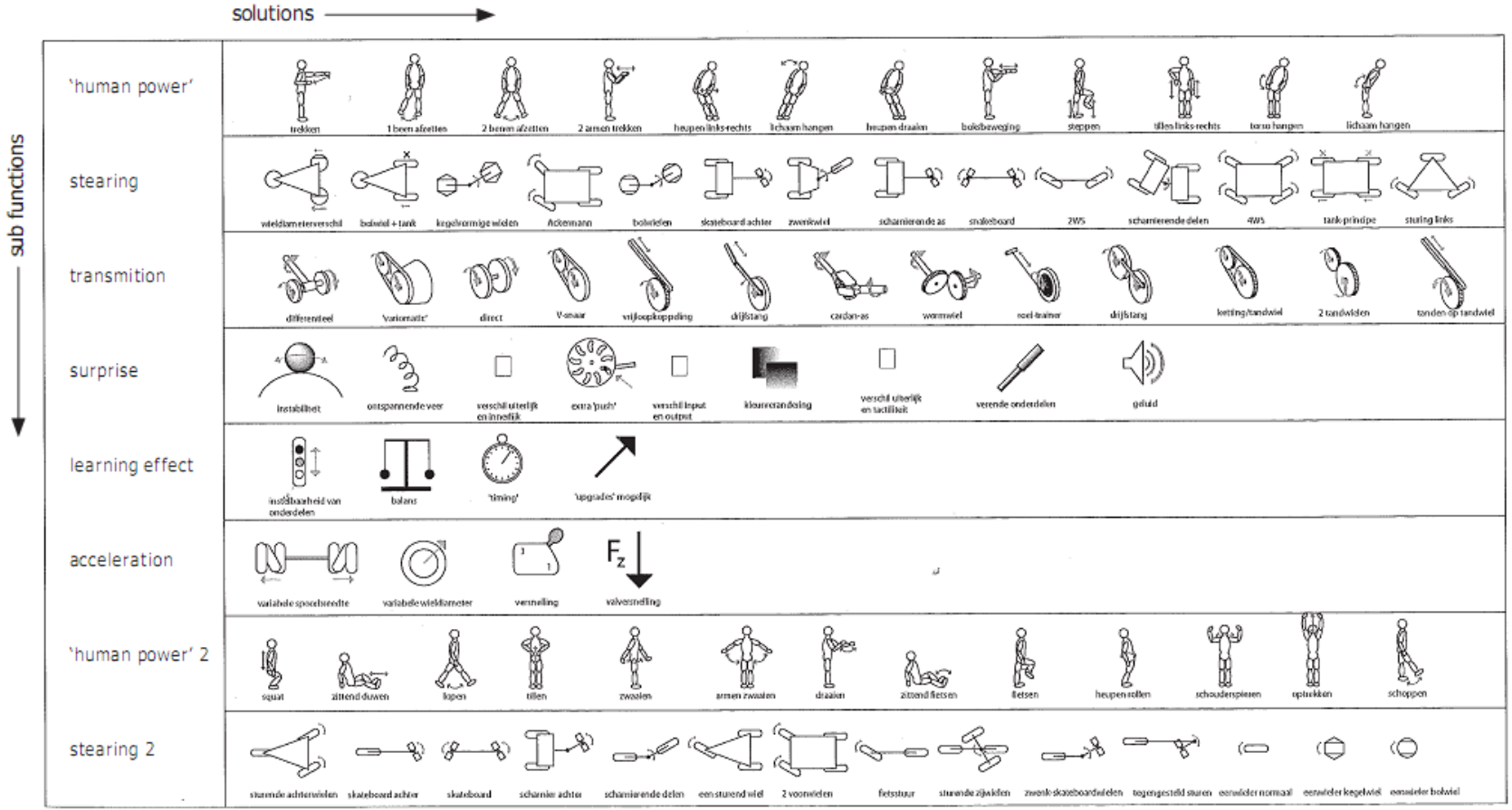
Goal:

- Create as many distinct solutions as possible.
- Create many possible alternative rearrangement of components
- Organize alternatives for future evaluations
- Classify alternatives

Morphology Chart (best for electromechanical design problems):

- Required functions/features along rows
- Different design alternatives and combinations along rows.
  - Phrases or sketches to capture the concept
- Sometimes other alternatives, such as concept diagrams or classification trees, are better suited to a given problem

Morphological Chart



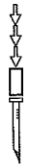
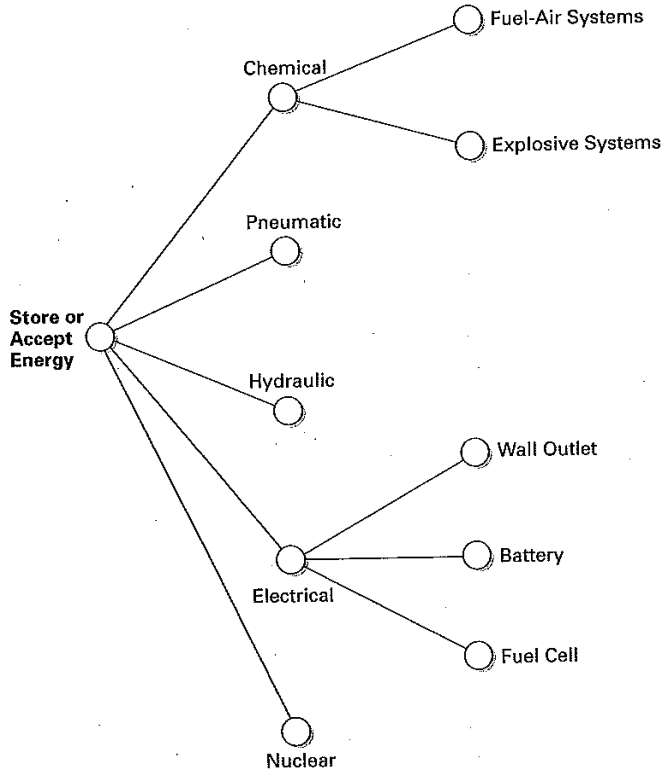
Solutions to Subproblem of Storing or Accepting Energy	Solutions to Subproblem of Applying Translational Energy to Nail	
• Self-regulating chemical reaction emitting high-pressure gas • Carbide (as for lanterns) • Combusting sawdust from job site • Gun powder • Sodium azide (air bag explosive) • Fuel-air combustion (butane, propane, acetylene, etc.) • Compressed air (in tank or from compressor) • Carbon dioxide in tank • Electric wall outlet and cord • High-pressure oil line (hydraulics) • Flywheel with charging (spin-up) • Battery pack or tool, belt, or floor • Fuel cell • Human power: arms or legs • Methane from decomposing organic materials • "Burning" like that of chemical hand warmers • Nuclear reactions • Cold fusion • Solar electric cells • Solar-steam conversion • Steam supply line • Wind • Geothermal	Single Impact	
	Multiple Impacts (tens or hundreds)	
	Multiple Impacts (hundreds or thousands)	
	Push	
	Twist-Push	

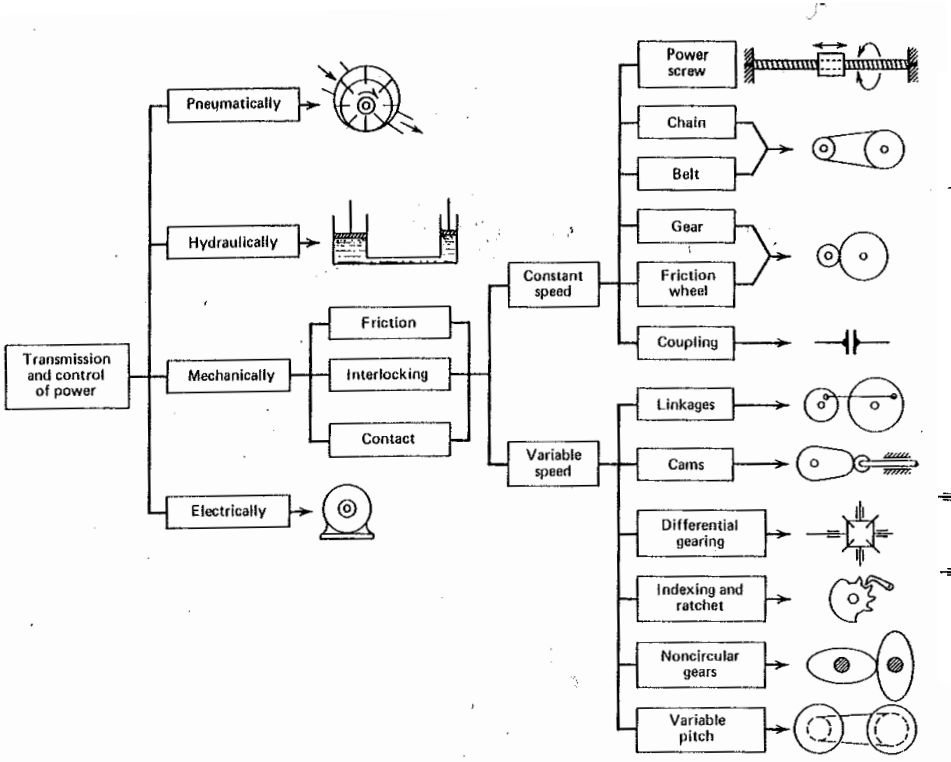
EXHIBIT 6–6

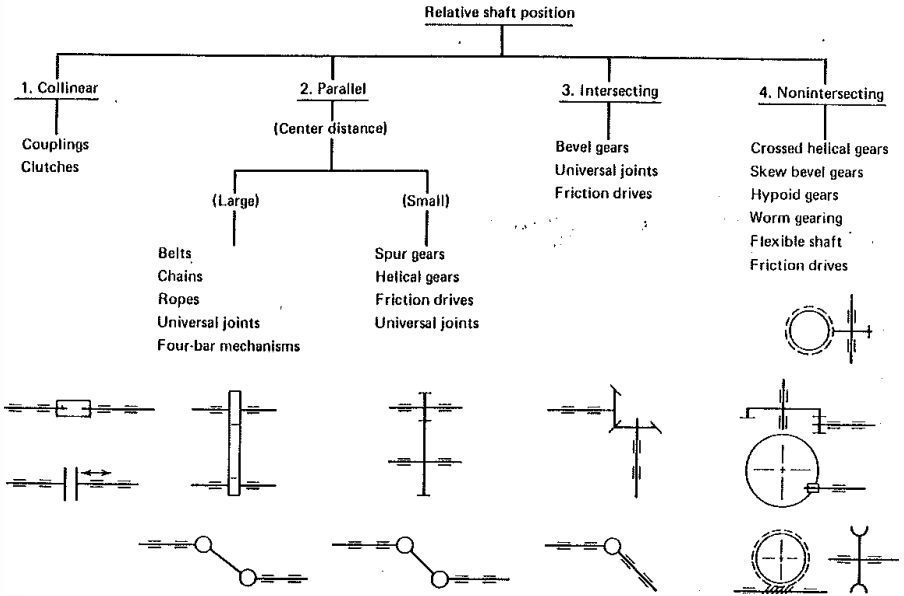
Some of the solutions to the subproblems of (1) storing or accepting energy and (2) delivering translational energy to a nail.

EXHIBIT 6–7

A classification tree for the nailer energy source concept fragments.




Transmission and control of power
Pneumatically
Hydraulically
Mechanically
Electrically
Friction
Interlocking
Contact
Constant speed
Variable speed
Power screw
Chain
Belt
Gear
Friction wheel
Coupling
Linkages
Cams
Differential gearing
Indexing and ratchet
Noncircular gears
Variable pitch


Relative shaft position
1. Collinear
Couplings
Clutches
2. Parallel
(Center distance)
(Large)
Belts
Chains
Ropes
Universal joints
Four-bar mechanisms
(Small)
Spur gears
Helical gears
Friction drives
Universal joints
3. Intersecting
Bevel gears
Universal joints
Friction drives
4. Nonintersecting
Crossed helical gears
Skew bevel gears
Hypoid gears
Worm gearing
Flexible shaft
Friction drives

Homework

Individual Tasks: If you haven't completed these tasks, please do it now!

- Get an account on GitLab: gitlab.robotics.caltech.edu.
- Get a slack account
  - Ask to join caltechcseeme75.slack.com
- Propose to Joel a separate 1-hour/week team meeting time

Team Tasks: (all unit levels)

- Create a Team project page on the course wiki
- List of specifications
- Function diagram

Homework

Team Tasks: (6+ unit level)

- **RC Car:**
  - Meet with Jake/Anushri to learn how to drive the car
  - Add/move existing cad files to new GitLab project directory

- **Drive-O-Copter:**
  - Meet with Arnon Lewinstein (lewinstein@gmail.com) to get CAD models/update.
  - Make plans to build a prototype!
  - Contact Drew Singletary (asinglet@Caltech.edu) and Anushri Dixit (adixit@Caltech.edu) to start learning about autonomy stack?
  - When is our weekly meeting time?

- **Extreme Localization:**
  - Contact Ben Morrel (Benjamin.morrel@jpl.nasa.gov) to learn about UWB efforts
  - Contact Ed Terry (eterry@Caltech.edu) for Total Station Info