Creating the “perfect” capstone project from proposal to hand-off

Mark Easley

Texas Instruments University Program

Workshop overview

We will cover

- **How to navigate your unique capstone program for efficiency**
- **Attract corporate participation**
- **Incentivizing your students, mentors, sponsors**
- **Getting better results out of your design projects**
- **Perfecting the art of asking for help and resources**
- **Advice on capstone resources**
- **Q&A on technologies accessible for student projects**

Texas Instruments

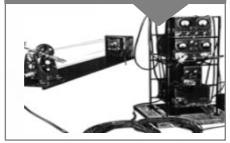
Mark Easley (measley@ti.com)
University Marketing Manager
Raleigh, NC

Software Engineer
Over 9 years at TI
Embedded Systems
& IoT experience

Our history of reinvention

1930s
Oil exploration

1940s
Defense systems



1950s
Integrated circuit

1970s
Microprocessors

1980s
DSP, DLP® Cinema

2000s
Analog and Embedded

2000s
Applied research – Kilby Labs

Present day
Industrial and automotive technologies

Experience matters with over 90 years of innovation

Reaching students and faculty @ university.ti.com

The Texas Instruments University Program is dedicated to supporting engineering educators, researchers and students worldwide.

TEXAS INSTRUMENTS

Teaching materials	Research labs	Design projects	Course Curricula	Teaching labs





Customers count on us to deliver great products, engineering expertise and support

PORTFOLIO

- Analog Power Products
- Analog Signal Chain
- Embedded Processing
- High Volume Analog & Logic
- DLP® Products

Key markets

- Industrial
- Automotive
- Personal electronics
- Communications equipment
- Enterprise systems

Manufacturing

- 200-mm
- 300-mm
- Quality and reliability
- Supply continuity
- Multi-sourcing
- On-time delivery

Support

- Easy part selection
- Reference designs
- Online support
- TI.com
- Training
- Technical sales and support
- TI store

Let’s take a quick look at how we manufacture products at TI

Semiconductor Industry

sand

silicon

layer

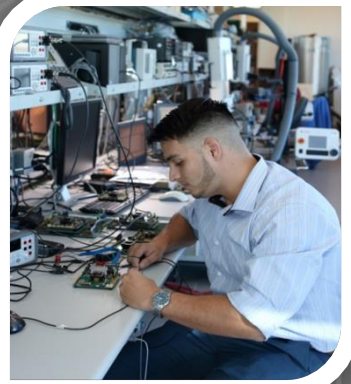
Embedded Processing

Texas Instruments

Analog

Texas Instruments

interconnect



Texas Instruments

Everyday electronics that use TI technology

Smart phones

Test equipment

Medical

Wireless infrastructure

Smart energy meters

Wireless LANs

Automotive & HEV

Digital TV

IP phones

Motor control

Computing

Industrial weigh scales

Digital still cameras

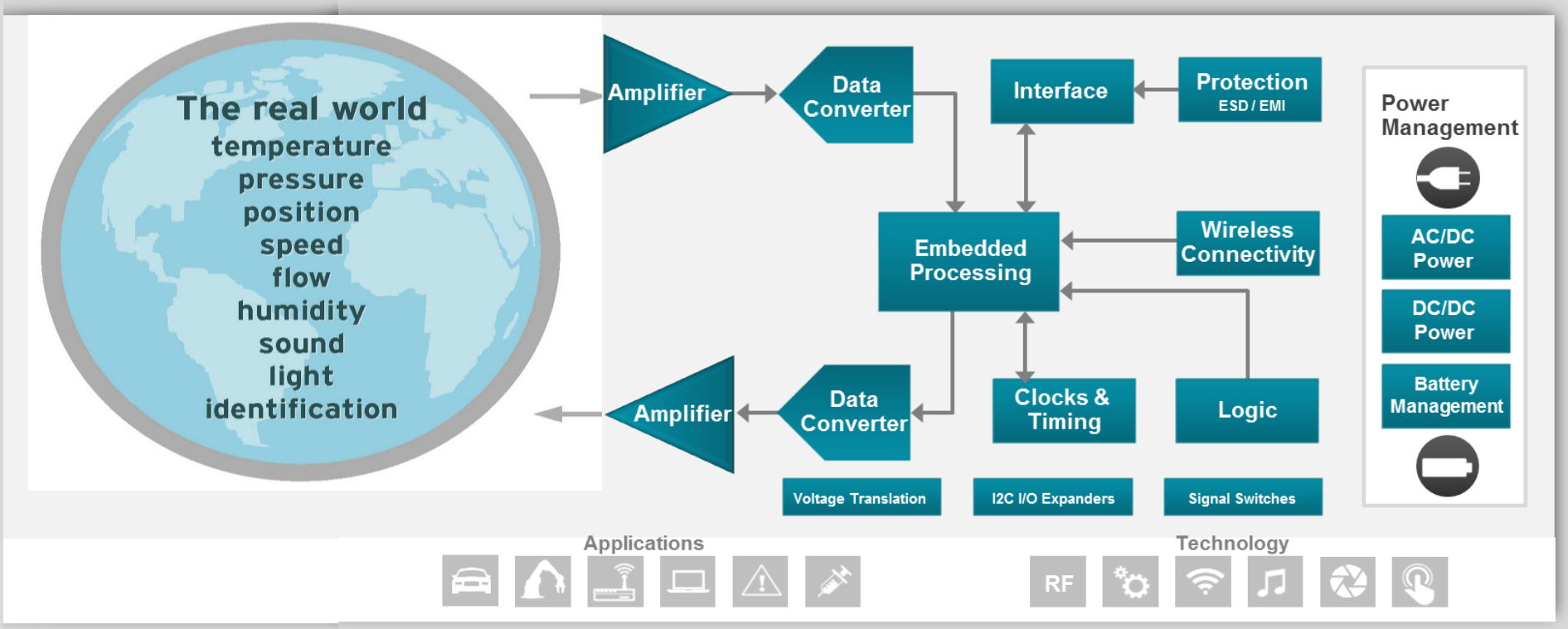
eBike

Digital audio & radio

Digital video recorder/server

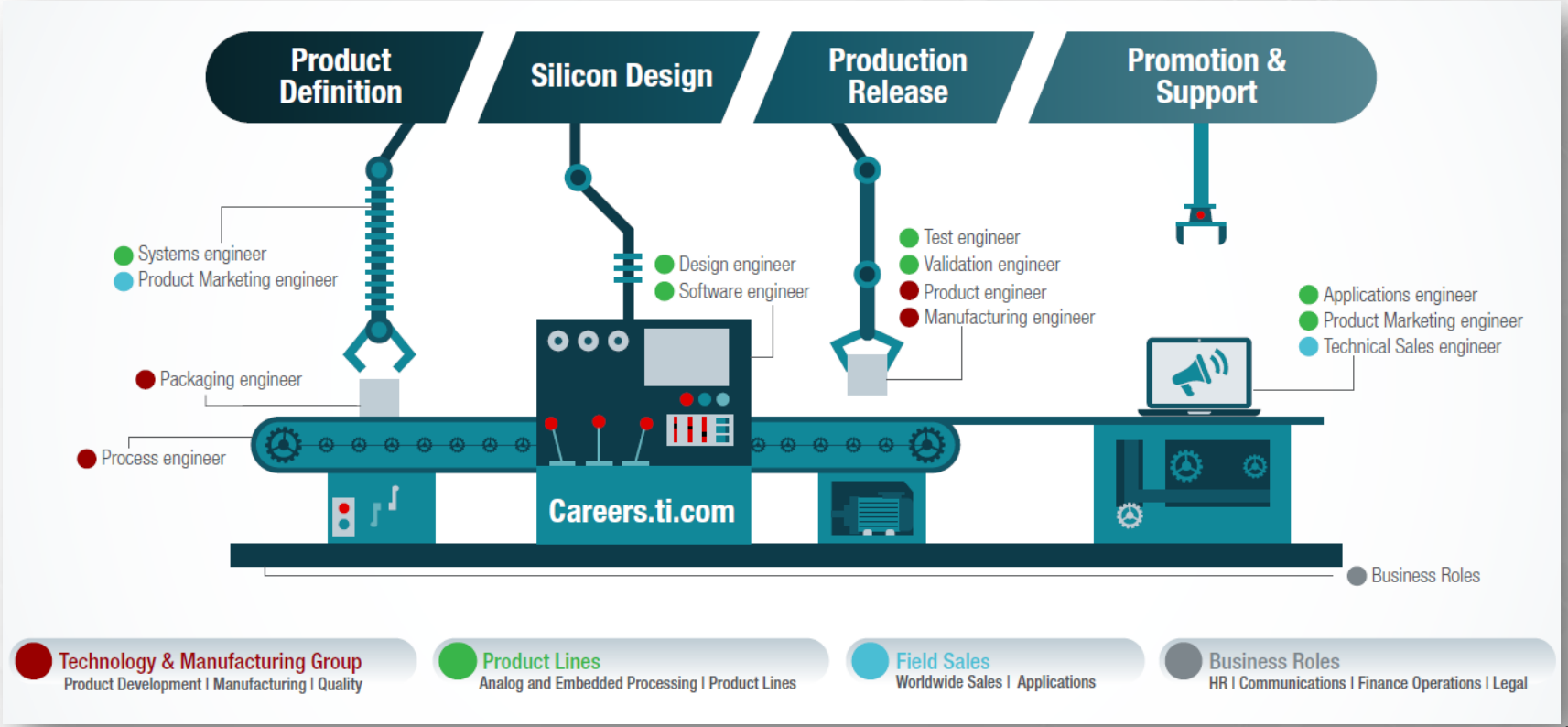
Analog and Embedded Processing

TI technologies at the heart of every system



Signal chain from the real world to the digital realm

Engineering Positions at TI



Diverse and global workforce

More than
30,000
Employees in
35 countries

Electronics and Semiconductor is a Global business

Chance to work in major cities across the nation and even the world!

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Inject industry relevant videos for context

Industrial processes

- **Commercial 3D printing**
- **Injection Molding**
- **PCB Manufacturing**
- **Semiconductor Manufacturing**
- **Steel and metal fabrication**
- **Food factory production**
- **Power plant, energy generation, and electricity distribution**
- **Lumber and wood processing**
- **Automotive assembly line**
- **Building construction**
- **Chemical and pharmaceutical manufacturing**

Where to get the videos?

- Google, YouTube, ask your industry network for company videos, TV show clips

Disclaimer: No such thing as a perfect project

Success Factors

- Students + Experience
- Motivation + Enthusiasm
- Noise + Environment
- Project planning
- Scope
- Stakeholders
- Equipment Access
- Team makeup
- Skills
- Time constraints
- Mentor commitment
- Mentor competency

Control what is in your control

- Training, environment, mentors

Disclaimer: Prepare your grain of salt

Everything is unique at every capstone program, what works well in one may not work as well in another

Program differentiators:

- Budget
- Stakeholders
- Administration support
- Region, Prestige, Ranking, Alum network, Endowment
- University size
- Scholastic culture

Disclaimer: Electronics are unique

The following materials will be from the perspective of an ECE project or any project involving hardware design. Has some general applicability but EE and Computer Engineering and Multi-disciplinary project with electronics will benefit most.

Electronics projects require:

- Software… a processor is involved more times than not
- Prototyping… hardware starting with off the shelf components, wiring and breadboarding
- PCB design… CAD software available as open source, free license, paid license
- Debugging… scopes, test & measurement, power supplies, DMM
- System integration… putting the parts together can be more challenging than designing

Questions?

Pause for Questions

Program type

Multidisciplinary vs department specific (single discipline)

- Focus
- Resources

Student driven vs sponsor driven

- Students ultimately decide what they work on
  - » Higher motivation, poor scope
- Sponsors decide what the students work on
  - » Demonstrated need, better scope, more mentorship required

Multidisciplinary sponsor driven program

Multidisciplinary

- More variety of projects, diverse project outcomes
- More resources can be shared and combined

Sponsor driven

- Need to develop a good pipeline of sponsored projects
- Sponsors decide what the students work on, can provide domain experts as mentors
- Have to encourage good mentors and discourage bad or unengaged mentors
- Project scope may be too large or require over specialization
- Project expectations may be too high for smaller sponsors and too low for larger sponsors

Department specific student driven program

Department specific

- Ability to focus projects and focus expertise required to mentor and evaluate the projects
- Resources can be concentrated to support the requirements of the department
- Limitations on working on certain types of projects or prototyping those projects effectively

Student driven

- Wide variety of projects based on student creativity and interests
- Sometimes students don’t know what to work on, need some feeder projects

Level of polish

Are you ok with simple prototypes? (Proof of concept)

- Cobble together development boards and off the shelf hardware
- Supplies from home improvement and hardware stores or online

Are you expecting custom designs? (Application demonstration)

- Printed circuit boards
- 3D printed enclosures
- Laser cutting, machining

Are you encouraging design for manufacturing? (Product design)

- Iterate design two or three times for optimization
- Form factor optimization

Student incentives

Prizes or Awards

- End of year awards, people's choice voting awards amongst peers and stakeholders
- Optional prizes (cash, gift cards, tools, bookstore apparel)
- Take advantage of the students' desire to compete as a minor motivation factor

Freebies

- Get sponsors or department to provide some goodies or tools to the class
- Donut day or pizza party to break up the stress

Student communications

Make sure students are set up to communicate amongst teammates

- Collaboration tools
- Meeting times, meeting space

Make sure students are getting class broadcasts and open lines to the instructors

- Email or classroom management strategy
- Regular checkpoint meetings

Project Showcase

End of semester or end of year

- Showcase final demos, posters, oral presentations
- Project judging live or on demand
- Virtual showcase
  - » Gather, Gatherly
  - » Zoom
  - » Self managed capstone website

Utilize online tools to archive project results

- Hackster.io, Instructables, Devpost, Youtube

Promote student achievement through social media

- LinkedIn, FB, Youtube, alumni newsletters, print

Questions?

Pause for Questions

Team Formation

Ideal team size

- 3-6 team members is best
- More students on a team de-risks projects and can help them get further with a design
- Less students on a team will push the students to learn more and can improve cohesion

Team mix

- Students
- 1 or 2 mentors per team
- 1 assigned faculty advisor or capstone advisor

Where to source projects?

Generic project prompts

- Work with capstone colleagues to find areas of common design projects that are timeless and technically challenging

Faculty & research labs

- Easiest to integrate into the program
- Can recruit volunteer mentors and project advisors

Corporate

- Recruit ideas and mentors to support the projects
- Is their motivation IP (making use of the project deliverables) or student access (recruiting) or campus participation (philanthropy)?

Corporate partnerships

Local, Local, Local

- Your biggest supporters are going to be regional companies
- Incentivized to hire local students, see local community grow and prosper

Career Center and Foundation

- Utilize your local networks to find program partnerships

Companies that hire your students

- Lastly make contacts with companies that would be interested in working on relevant projects – conferences, online networking, alum network
- May not be local… what are strategies to gain and retain these relationships?

Corporate partnerships

Retain good mentors and sponsors

- Get mentors that are repeatable, that students enjoy working with, that yield good results
- Have flexibility for consistent sponsors… budget changes, market changes, personnel changes, you can repair those relationships in the future if you plan ahead and widen your network

Project funding

- Utilize your local networks to find program partnerships
- Look for companies where funding is already coming into the university (Foundation, career center, etc) so it is easy to switch on for both sides

Get connected with the companies

- Report out the great project results the students are doing beyond the direct mentor
- Widen network by having multiple contacts in a company who are plugged in to capstone and can be a resource to navigate hand offs if contacts change roles

Corporate partnerships

Alignment with existing initiatives

- Engineering competitions
- Student competition team sponsorships… projects related to competition teams
- Mutual connection with community effort for example youth programs like Girl Scouts, environment, Public library system, social concerns like homelessness, city or regional government or community policy, etc. and projects related to those areas

Get connected with the companies

- Report out the great project results the students are doing beyond the direct mentor
- Widen Network by having multiple contacts in a company who are plugged in to capstone and can be a resource to navigate hand offs if contacts change roles

Intellectual Property and NDA

Fully support corporate

- All IP delivered to the project sponsor, very clear

Fully support open source

- Don’t worry about IP and communicate to companies and students that projects must be open

Struggle in the middle

- If you don’t pick a plan, you will run into conflicts and added frustrations

Focus on factors under our control

In design courses we are dependent on the students' prerequisite knowledge, but not all knowledge is equal, nor will prior work translate to their project

- Tactic 1: Skill up the students
- Tactic 2: Provide strong mentors
- Tactic 3: Provide proven project prompts
- Tactic 4: Provide the standard resources with high utility

Skill up the students

Provide technical training on the key areas of electronics design and manufacturing

Connect them with the lab staff so they can get confidence in using equipment and machinery they haven’t likely used before or often

Give them supplemental resources to research and study at the beginning of the project as they are refining their proposals

Provide strong mentors

Each capstone program is a little different but typically relies on voluntary participation from subject matter experts including faculty, staff, alums, and corporate sponsors

The strongest mentor guidance will be from faculty mentors

- Students are comfortable with the dynamic of getting help from professors
- Does the faculty member have the time or motivation?
  - If yes, keep encouraging!
  - If not, best to cycle to other volunteers

Additional mentor guidance provided by alum or corporate mentor

- Students introduced to more professional interactions
- Does the mentor have the time or motivation?
  - If yes, keep encouraging!
  - If not, best to cycle to other volunteers

Provide strong mentors

How to recruit good mentors?

- Referrals
- Alumni network
- Corporate partners and industry advisory board

How to retain good mentors?

- Engage and keep communication active
- Incentivize with recognition awards, discount or free projects, or other retention tactics

How to attract new partners?

- Capstone faculty network
- Local engineering focused businesses
- Career center network

Provide proven project prompts

Example project prompts

Design an IoT device

– Translation: create an embedded system with a wireless application

– Preparation: Use a particular standard dev board to start prototyping, then design a custom PCB using that prototype circuit, add an enclosure

Design a Robot

– Translation: create an embedded system with motor control

– Preparation: Use a standard low cost kit that is fully integrated to start prototyping, either carry that through with software that will run on that platform or design a custom chassis and circuit

Open-ended to enable creativity, but learning objectives and technical challenges of each project are clear and formulaic

Provide the standard resources with high utility

Students will need to quickly prototype their solution for the proof of concept demo and then move into a custom design

“Standard” being the operative phrase, this helps streamline the training resources and the expenses year after year, bias toward industry tools where possible

Things that cost money

- Development boards (microcontrollers, microprocessors)
- Components, breakout boards, sensors, motors, etc.
- 3D printing and other rapid prototyping

Things that don’t cost money

- Existing campus software licenses (CAD tools, Solidworks, MATLAB, etc)
- Space to work, shared equipment that is accessible

Product Development
a birds eye view

Hardware is hard, so you need to have a plan and understand the product development cycle

Summary from Maker.io

1. Concept
2. Research
3. Evaluation
4. Design
5. Prototyping
6. Funding
7. Marketing
8. Production
9. Distribution
10. Support

Product Development
a birds eye view

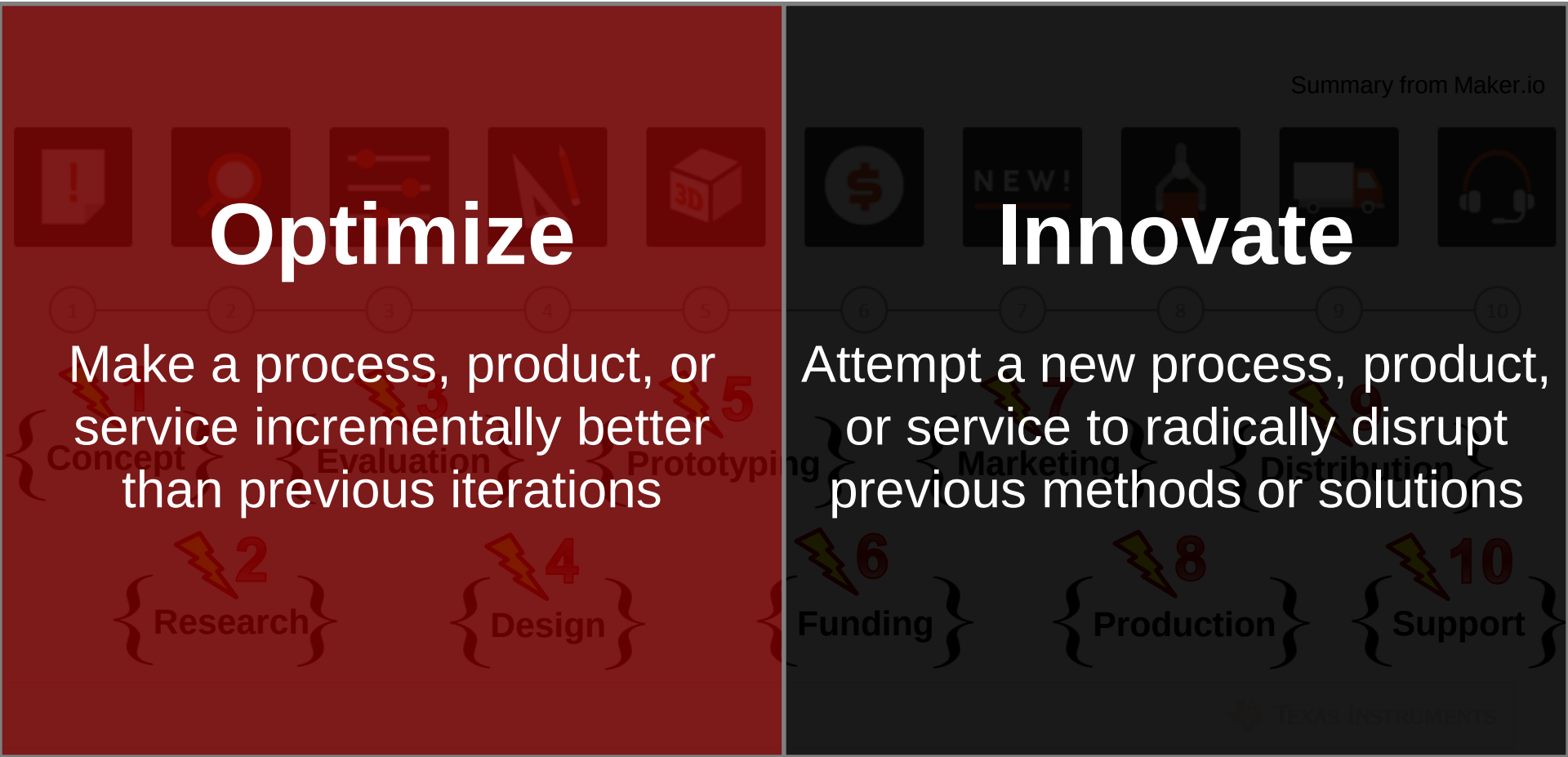
Two major tasks in design and engineering – both have value!

Optimize

Make a process, product, or service incrementally better than previous iterations

Innovate

Attempt a new process, product, or service to radically disrupt previous methods or solutions



Questions?

Pause for Questions

Capstone for Remote Work

The concept is here to stay, help the students harness it

1. Scope the project appropriately so work can be accomplished as a distributed team if that is required

2. Be prepared in case a team member gets sick or has to drop the course, know what everyone is working on

3. Try to use software that can be run on your local machine or in the cloud in case you have to take your work home

4. For hardware portions, plan to utilize prototyping solutions you can do at home

5. Manage software through Github or other version control tools

6. Use collaboration tools so team can be updated on changes to the project

Capstone for Remote Work

For electronics projects…

Development boards and premade modules are best to start with on prototype design working toward proof of concept

Ordering PCBs is possible, but be careful for delays on parts and assembly

While working remotely you may have limited equipment access, so things like soldering, testing and debug may be constrained, plan ahead to acquire the equipment you might need so there are no gaps in progress

Project proposal to handoff

Collecting proposals

- Keep organized
- Have a form and template
- Manage expectations… scope, quality of students, access to resources
- Go all in on IP preservation or all in on open source
- Cast a wide net, can always pare down later

Engage students constantly, check in with mentors

- Regular review meetings
- Survey mentors at end of each semester and mid term (check on progress, team dynamics and if corrections need to be made, gauge mentor engagement)
- Allow mentors to give a periodic grade or direct feedback to the team on project progress every few weeks or at the end of the semester

Project proposal to handoff

Project timelines

- Gantt Charts, Kanban boards, other tools to keep students tracking progress and issues

Provide project resources on demand

- Capstone lab equipment and shared university resources
- Ordering system… buy parts online, have students
- Manufacturing… 3D printing, order PCBs, lasercutting

Handoff to sponsors

- Provide deliverable system, make this part of their final grade
- Make sure teams are accountable to give their key items to the sponsor (github repositories, final report, link to oral presentation video, physical prototype, etc)

Thanks!

Q&A

Mark Easley (measley@ti.com)

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