

[Morse code beeps]

[Whoosh]

[Helicopter rotor]

Hello.

Welcome to the Formulating a Research
Topic workshop.

My name is Evan Kramer.

I'm an AeroAstro Communication Lab Fellow,
and I will be your instructor today.

To get started let's take a moment
to consider what quality research is.

We all strive to produce it,

but definitions

of quality vary from person to person.

However,

there are some general characteristics
that apply across the board

which we will cover in this workshop.

Please

pause the video and spend five minutes

listing and providing rationale

for a set of characteristics

you believe research must possess

to be considered

quality.

[Alien spaceship beeps]

Now that we're primed

to talk about research

topics, here's a list of our lesson goals.

After this workshop,

you will be able to understand

common characteristics of quality

graduate school research, implement

a framework

for formulating a well-defined research

topic,

and pursue next steps for formalizing

your initial research topic formulation.

So quality research, what is it?

Generally, quality research in graduate

school possesses three characteristics.

It is independent, meaning

it can be conducted entirely by you

without assistance from outside resources.

It is important, meaning

it makes a contribution towards

answering a specific question

or gap in knowledge

raised by several scholars

within the research community.

And it is unique,
meaning that
it makes a first of its kind contribution
by either addressing
a previously unanswered question
or introducing a novel solution
approach within an existing body of work.
We've established some general criteria
for what entails quality research,
but how do we actually formulate
a research topic
that embodies those characteristics?
The first step is to acknowledge,
that to perform quality research,
you must have a well-defined
research topic.
Formulating a well-defined research
topic requires significant effort,
but this effort is necessary
to avoid running into unforeseen
challenges during your Ph.D.
It is
important to emphasize that this process
takes time.
While it may be tempting
to try to rush into a project,
try to keep in mind that your chances
of crafting a robust and cohesive research
topic during
graduate school is highly correlated
with the amount of time and effort
you spend during the formulation phase.
We present a five phase
framework in this workshop
that can be implemented
during the formulation
of your research topic.
We'll go into each phase on the following
slides.
The first phase involves
personal reflection.
Based on previous experiences
and coursework, internships,
and extracurricular activities, create
a two column list.
The first column lists research fields
you found interesting.
For example
you might have had a summer internship
where you were exposed to space propulsion

work.
Or, you might have taken an undergraduate.
Course in aerospace controls
that you particularly enjoyed.
Note that these topics are
specific enough
to carry out some exploratory reading,
but general enough to avoid unnecessarily
over constraining you at an early stage.
The second column lists ideas that align
with your personal motivations
to pursue a career in Stem research.
Your personal motivations
might be extremely diverse.
For example,
you may be passionate about increasing
equitable access to space capabilities
for low-resource nations
and enabling efficient disaster response
for remote communities.
There are no wrong entries
for this column.
Anything that drives you to spend the next
2 to 5 years
performing research in STEM belongs here.
Let's practice
looking inwards in an activity.
In the Research Topic Formulation
worksheet, fill out the left and middle
columns.
Take ten minutes to get some ideas down,
but feel free to revisit this table later,
as this sort of personal reflection
should not be rushed.
[Alien spaceship beeps]
Great job reflecting.
With the entries
you've written in your table, start
familiarizing yourself
with the current state-of-the-art.
A good place to start
would be popular science media outlets.
Try places like Space.com, The Verge,
and Scientific American
for high level, accessible articles.
As certain entries in your interest column
pique your interest, start to perform
deeper dives into your related academic
literature using Google Scholar.
It is likely that several of the topics

in the left column of your list
get crossed off really quickly, as
you realize they no longer interest you.
Try to narrow down your list of interests
to about three before
proceeding to the next step.
After you've reflected, and done
some reading into your topics of interest,
it is time to expand your
table with a third column.
While personal interests and
motivations are central to topic
formulation,
external factors must be considered too.
You'll need to consider the priorities
of who your funding is coming from,
and you'll need to consider
areas of your lab's research thrusts.
The third column of your table
will capture
these external requirements.
An example for a funding requirement
might include ensuring your work
integrates elements of testbed development
for satellite dynamics
and control algorithm testing,
if a grant that is funding
your work was written
focusing on this research area.
An example for a lab's research
thrust might be A.I.
applied to satellite operations,
if that is where your advisor's expertise
and active research interests lie.
If you're unsure
about what belongs in this column,
schedule a meeting with your advisor
to discuss what external constraints
you should consider
during the topic formulation phase.
The next step in our
framework
is to formulate a research statement.
This is exciting because we're now
starting to bring together
all of the pieces that you've been working
on separately.
Research statements should be in
"To...By...While" format.
This format explicitly identifies

what you are trying to accomplish,
how you will accomplish it,
and which constraints you will consider.
Your table of entries contains
the information needed
to write your first draft
of a research statement.
A possible research statement
could be defined with one entry
from each column,
or you may be able to create a topic
with multiple entries from each column.
An example research statement
from the previously shown table entries
is, "To enable efficient natural disaster
response for remote communities
by developing an A.I.- powered
rapid response scheduling algorithm
for a remote sensing satellite
while accounting for limitations
to satellite operations
imposed by the space environment."
Implementing this
research statement format
by referencing your table entries
not only describes what you'll do, how
you'll do it, and within what constraints,
but it also ensures
that your own personal interests,
motivations, and relevant external factors
are captured in your formulation.
We'll now practice
writing a research statement.
The first step will be to write
some entries in the third
column of your table
for external requirements.
After that, and regardless of how mature
you feel your entries in your table are,
go ahead and draft a research statement
in "To...By...While" format,
that communicates what you're proposing to
do, how you'll do it,
and which constraints or assumptions
you'll be working under.
Please take ten minutes for this activity
before returning
to the workshop.
[Alien spaceship beeps]
Congratulations

on drafting your first research statement.
The last phase in the formulation
framework is to iterate
and track your work.
You'll end up creating several iterations
of research
statements
as you continue to read literature.
Your readings will inform how you iterate
on your research statements
language to pinpoint
exact gaps in knowledge.
As you continue to read,
formulate a focus area Venn diagram
where your topic is at the center
and related literature gets organized
into regions surrounding it.
This diagram will help you stay organized
and track all of the papers that you read.
It is also a really useful way to visually
describe the research that you perform.
You might even find it
useful to include in presentations
you give, including your Ph.D.
proposal defense down the road,
since it effectively contextualizes
your research topic.
You've now completed
all the steps in the research
topic formulation framework.
So what exactly comes next?
After initial formulation comes official
formalization of your research topic.
Formalization involves
the addition of more structure to what
you are working on
by clearly articulating why
and how you're going to perform it.
Central to articulating
why and how you're performing
your research is a gap analysis
that frames your work
within the context
of the current state-of-the-art.
The concept is similar to the reading
you did during formulation,
but now it is extremely focused
in the sense that you need to amass
a set of papers that describe
the current state-of-the-art for the topic

you're focusing on and what they're clearly demonstrated limitations are.

An example gap analysis is shown in the table at right, where the focus area of the topic is radiometric terrain correction for synthetic aperture radar satellite imagery. The current state-of-the-art is summarized in the middle cell and the limitations of the current approach are listed in the bottom cell, with citations to the literature references that point out these gaps. After you've completed your gap analysis, you'll have an extremely robust and documented case for why the research you are pursuing is worthwhile. With a gap analysis in hand, you can progress to write the following. Focused questions serve as a stepwise set of milestones, posed as questions, that must be answered to address a focus area.

A Ph.D. research topic might have 3 to 5 focus questions, some of which are contingent upon answers to others.

Objective statements directly respond to focus questions and detail what you will do, how you will do it, and within which constraints.

These share the structure of research statements, but are narrower in scope. Contribution statements clearly defined the novel insights, advancements, and solutions your research offers to the field.

These are the statements you will claim you fulfilled when you defend your Ph.D. dissertation down the road.

There is understandable uncertainty early on in the research formalization process.

You might not know how to write all of your questions, objectives, and contributions.

Your gap analysis should offer a starting point, however,

and as you progress
during your graduate school journey,
you can revisit language
in your statements.
Once you've completed the formalization
steps,
you have a solid course
charted for your graduate school research.
That concludes this workshop
on formulating a research topic.
You should now be able to understand
common characteristics of quality
graduate school research, implement
a framework
for formulating a well-defined research
topic, and pursue next steps
for formalizing
your initial research topic formulation.
I hope you find the
presented resources useful
in your graduate school research journey.
This workshop was created and presented
by Fellows of the MIT
AeroAstro Communication Lab.
You can find other workshops
related to technical communication
in our MIT OpenCourseWare repository.
Thank you.
[Morse code beeps]