Convergent Aeronautics Solutions Project

Transformative Aeronautics Concepts Program

AIAA Aviation 2018

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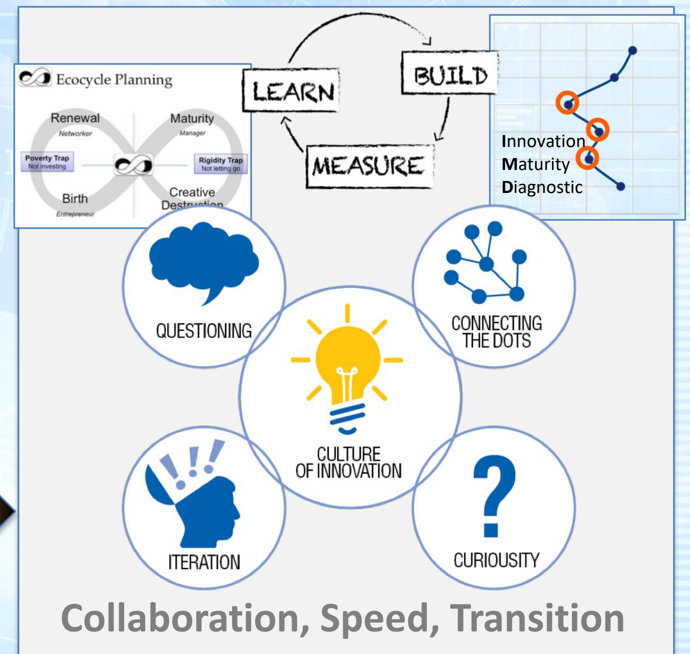
NASA Glenn Research Center

CAS Mission

Demonstrate feasibility of transformative concepts
and introduce cultural change
to align ARMD and the external environment.



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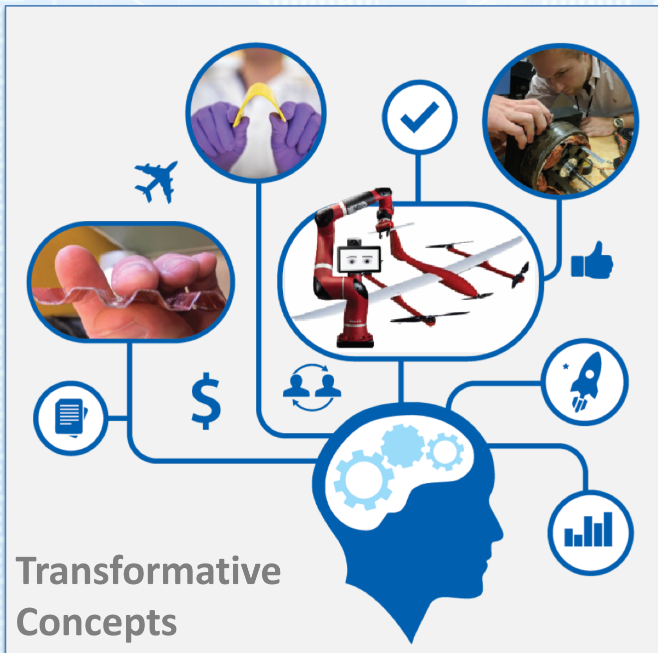
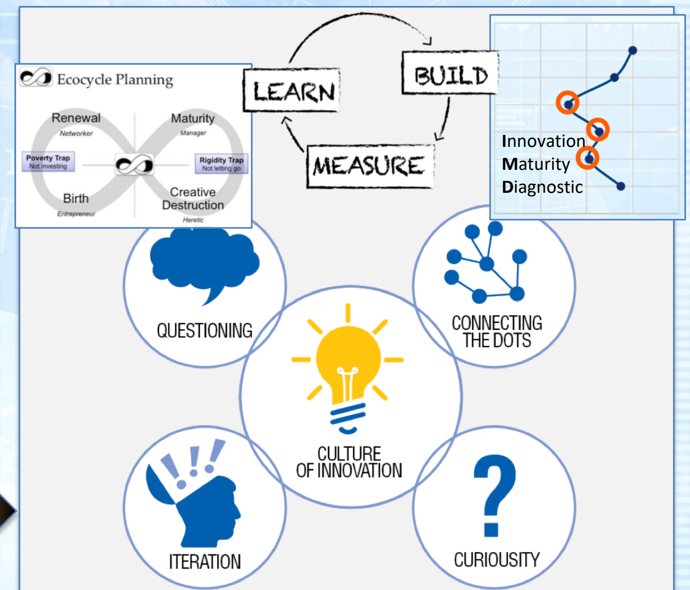
Yesterday's Presentation


Transformative Concepts



Collaboration, Speed, Transition

Today's Presentation

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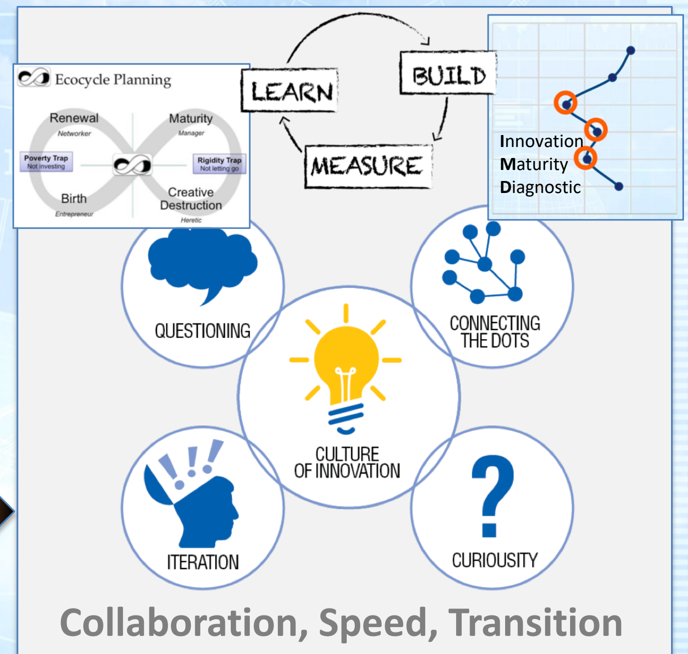


Tomorrow's Presentation

CAS Activities coming after this presentation

	Activity
Round 2 (2017)	Compact Additively Manufactured Innovative Electric Motor (CAMIEM)
Round 2 (2017)	Conformal Lightweight Antenna Structures for Aeronautical Communication Technologies (CLAS-ACT)
Round 2 (2017)	Fostering Ultra-Efficient, Low-Emitting Aviation Power (FUELEP)
Round 2 (2017)	LIthium-Oxygen (battery for) NASA (LION)
Round 2 (2017)	Spanwise Adaptive Wing (SAW)

CAS Activities

Innovative Ideas that are –

#1

Transformative
… BIG Impact

#2

Convergent

… Inter-Discipline,
Inter-Center,
Non-Traditional Partners

- Competitively Selected
- Light Project Management

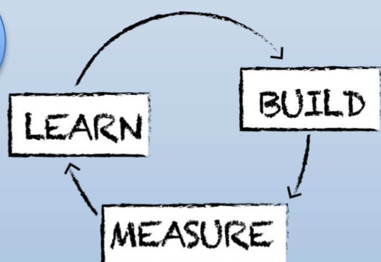
#3

Targeted
… As ONLY NASA Can

#4

Feasibility Focused
… Can it Work?

#5



Rapidly Executed
… Learn Fast & Move On

NASA ARMD Six Strategic Thrusts

1. **Safe, Efficient Growth in Global Operations**
   Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

2. **Innovation in Commercial Supersonic Aircraft**
   Achieve a low-boom standard

3. **Ultra-Efficient Commercial Vehicles**
   Pioneer technologies for big leaps in efficiency and environmental performance

4. **Transition to Alternative Propulsion and Energy**
   Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

5. **Real-Time System-Wide Safety Assurance**
   Develop an integrated prototype of a real-time safety monitoring and assurance system

6. **Assured Autonomy for Aviation Transformation**
   Develop high impact aviation autonomy applications

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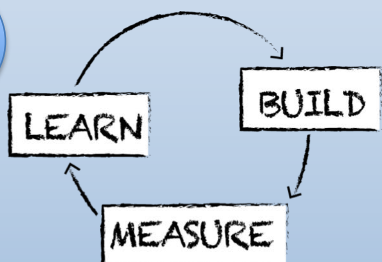

Rapidly Executed

... Learn Fast & Move On

CAS is Focused on Rapid Feasibility Assessment

What's a Feasibility Assessment and how is it different than a technology demonstration effort?

- Feasibility Assessment is Technology Evaluation
  based on extensive investigation and research to support the process of decision making.
  Short Term (0.5-2.5 yrs), rapid "build-measure-learn" - assess feasibility and move on
  - Understand where the concept works and where it does not
  - Understand the concept's broader applicability
  - Push the boundaries of concept effectiveness (even taking the concept to failure)
    Such as determine: When, How, and To What Extent, ... to Use the Concept
  - Consider important real-world "ilities" – e.g. Maintainability, Community Acceptability, Fly-ability, Cost, Interoperability, etc.
  - Not to suggest that all "ilities" will be considered, but identify the most important challenges and have them inform the feasibility approach
- A successful feasibility assessment may determine that the concept doesn't work

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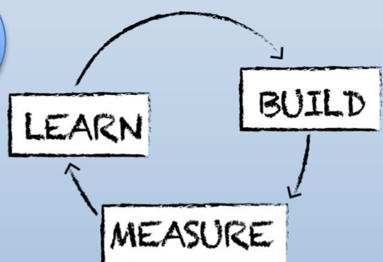

Rapidly Executed
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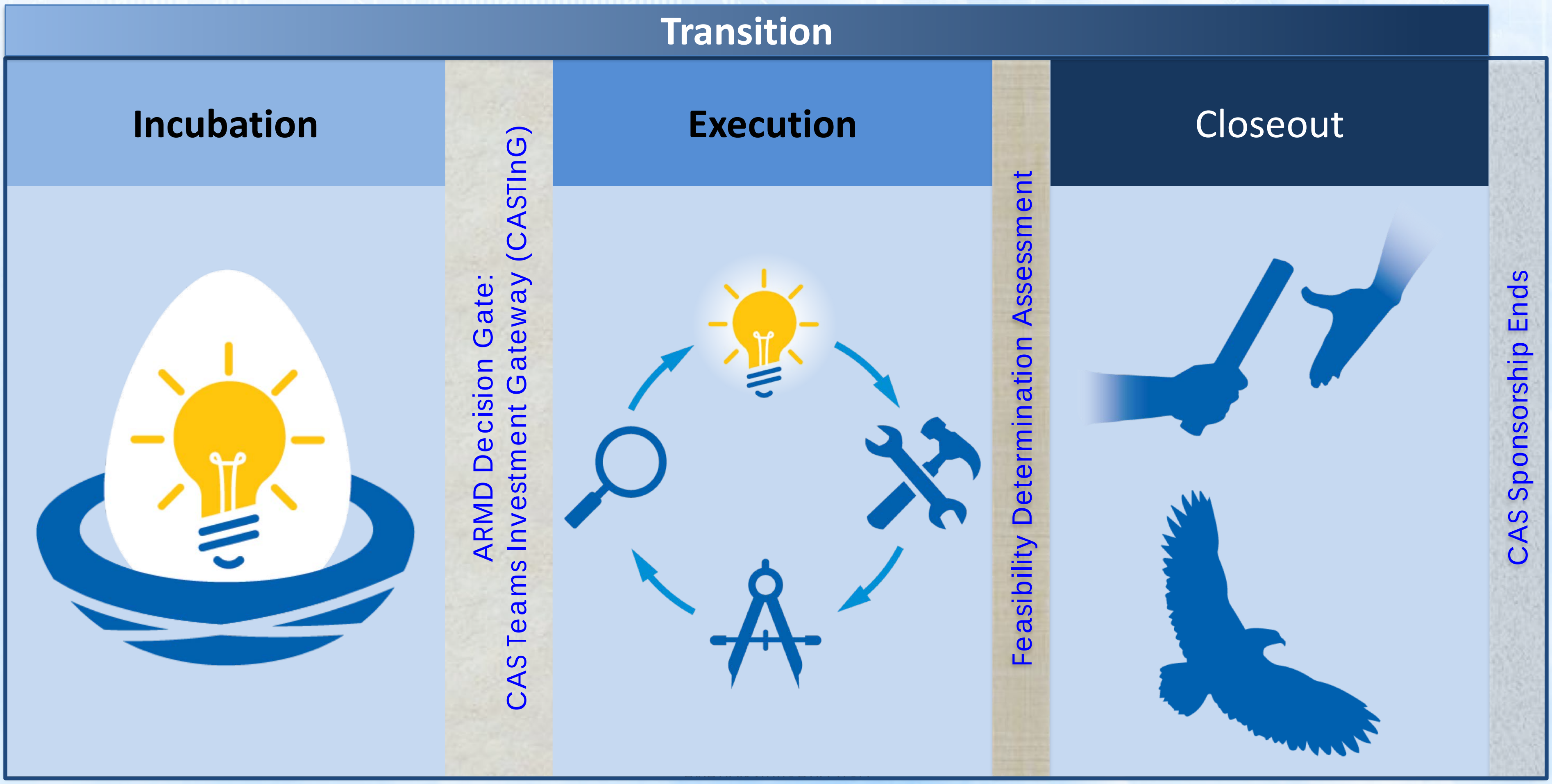
#4

Feasibility Focused
... Can it Work?

Managed by Phases



CAS FY18 Project Portfolio (FTE Allocations)

	Quarters in Execution																Thrusts/Outcomes						Proposed FTE/Centers			
	FY17 Q1	FY17 Q2	FY17 Q3	FY17 Q4	FY18 Q1	FY18 Q2	FY18 Q3	FY18 Q4	FY19 Q1	FY19 Q2	FY19 Q3	FY19 Q4	FY20 Q1	FY20 Q2	FY20 Q3	FY20 Q4	1	2	3	4	5	6	ARC	AFRC	GRC	LARC
FY18 (Round 3) New Start Sub-Projects																										
ATTRACTOR																	F				F	**M,F**	X	X		**X**
Fit2Fly																					**N,F**	N,F			X	**X**
QTech																	**M**				M,F	M,F	**X**		X	
FY17 (Round2) Sub-Projects																										
LION																			A	**A**			**X**	X	X	
SAW																		A	**A**					**X**	X	X
FUELEAP																			A	**A**				X	X	**X**
CAMIEM																			A	**M, F**				X	**X**	X
CLAS-ACT																	**M, F**		M,F			F	X	X	**X**	X
FY16 (Round1) Sub-Projects																										
Learn2Fly																	**F**		F			F				**X**
Digital Twin																			M		**N,M**					**X**
MADCAT																			**F**				**X**			
AOS4UAV																						**F**	**X**			
M-SHELLS																			M,F	**M,F**			X		**X**	X
HVHEP																			M,F	**M,F**			X		**X**	

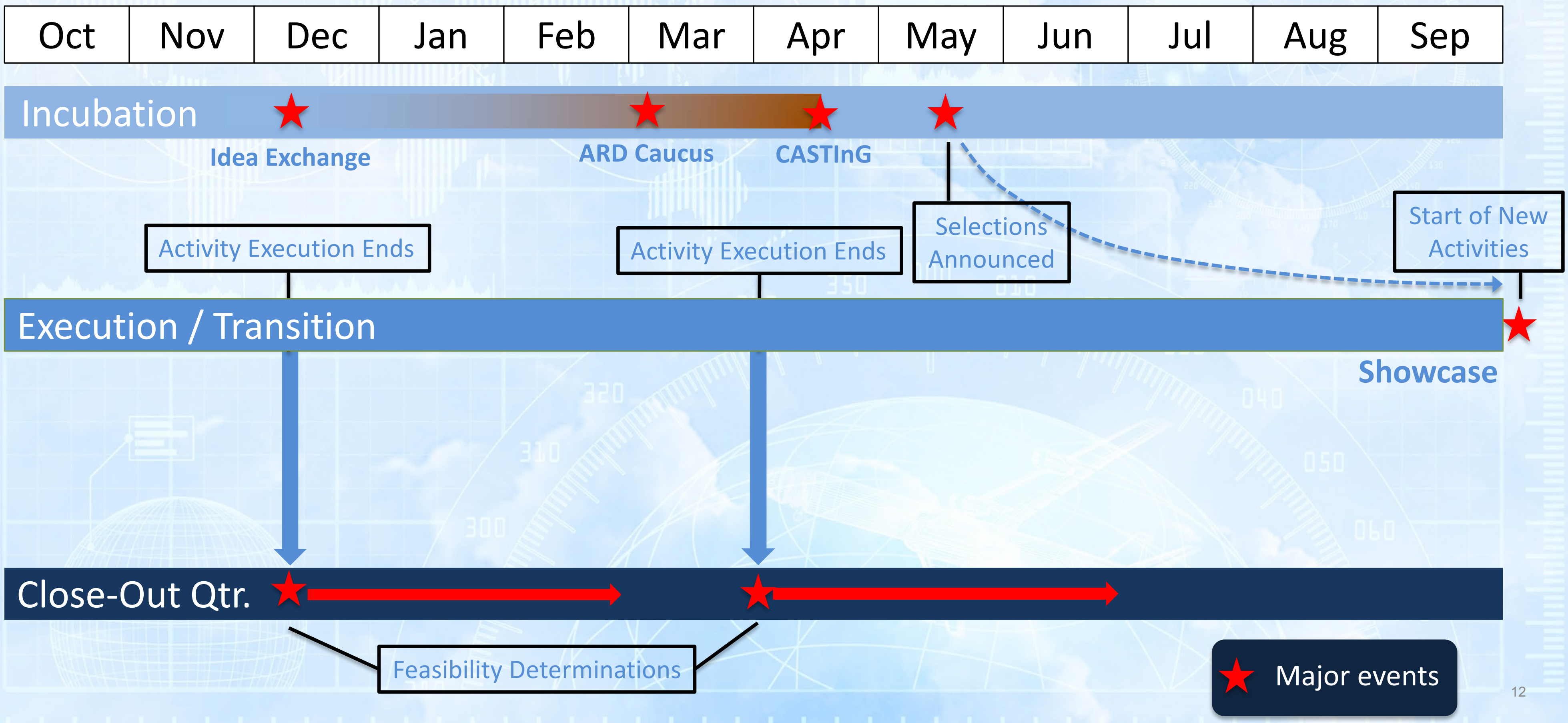
quarters in execution
quarters in transition/closeout
transition from CAS to Mission Projects

P Primary Thrust
S Secondary Thrust

Outcomes
N: Near Term (2015-2025) M: Mid-Term (2025-2035)
F: Far-Term (>2035) A: All Outcomes

X Home Center of Principal Innovator
X Partnering Center

Notional CAS Year



CAS Project Organization [FY18]

PROJECT LEVEL

PM: Isaac López
DPM: Marty Waszak

Center Liaisons: Starr Ginn (AFRC), Dr. Greg Dorais (ARC), Dr. Jerry Welch (GRC), Dan Williams (LaRC)

Execution Manager: Debbie Martínez
Transition Manager: Peggy Cornell
Business Lead: Christina Morris
Scheduler: Donna Gilchrist

Manager	Center Liaisons	Execution Manager	Transition Manager
Phase	Incubation	Execution	Transition & Close Out

Incubation

Next FY+[Round N] Concepts

Execution

Round 1 (FY16-18)	**Round 2 (FY17-19)**	**Round 3 (FY18-20)**
AOS4UAV	CAMEIM	ATTRACTOR
HVHEP*	CLAS-ACT	Fit2Fly
M-SHELLS*	FUELEAP	QTech
	LION	
	SAW	

** Activities in transition ending 3QFY18*

Transition & Close Out

Round 0 (FY15)	Round 1 (FY16-17)
SCEPTOR	AATC
X-Plane	Digital Twin*
DELIVER*	MADCAT*
Carry-in: VIPR3, Seedling,	L2F*

** Activities in transition ended 1QFY18*

Completed CAS Activities

	Activity
Round 1 (2016)	High Voltage Hybrid Electric Propulsion (HVHEP)
Round 1 (2016)	Mission Adaptive Digital Composite Aerostructure Technologies (MADCAT)
Round 1 (2016)	Learn to Fly (L2F)
Round 1 (2016)	Multifunctional Structures for High Energy Lightweight Load-bearing Storage (M-SHELLS)
Round 1 (2016)	Digital Twin
Round 1 (2016)	Autonomy Operating System for UAVs (AOS4UAV) *

* No summary presented

High Voltage Hybrid Electrical Propulsion

Objective:

- Evaluate feasibility of high voltage, variable frequency power system with self-healing insulation, doubly fed electric generators and propulsors, settingless protection system, and zero energy fault clearing.

Impact:

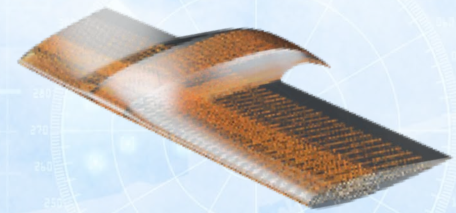
- Significantly reduces power electronics (85%), switchgear (>50%), and distribution weight leading to efficiency improvements and lower emissions.

Results:

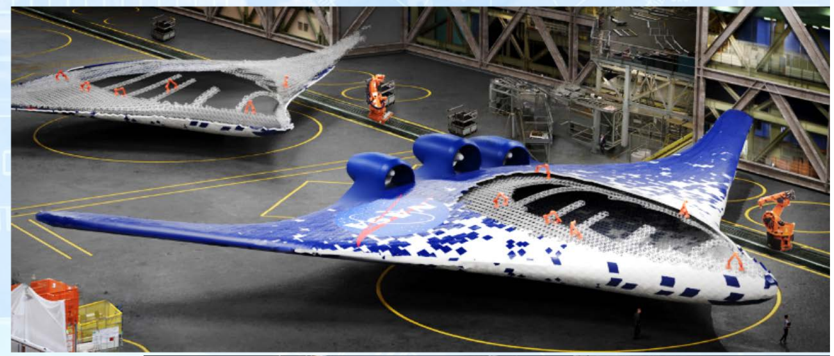
- The HVHEP System is effective at much **lower** power densities and bus voltage than the DC System!
- Ability to control real and reactive power (phase and voltage) using generator and propulsors provides more effective control than traditional power system method
- Propulsors become generators during throttle back and coast
  - Regenerative energy must be stored or dissipated
  - DFEM provides means to deactivate field to prevent regeneration rather than accommodate
- Ability to control load (ducted fan speed) provides more effective control than traditional power system methods
  - Traditional power system treats loads as disturbance with no ability for proactive control

MADCAT:

Objective:



- To demonstrate feasibility of a novel aerostructure concept that takes advantage of emerging digital composite manufacturing and fabrication methods to build high stiffness-to-density ultra- light structures (i.e. a digital materials (discrete, digitized structures) approach to making an ultra- lightweight and adaptable (reconfigurable) wings.)

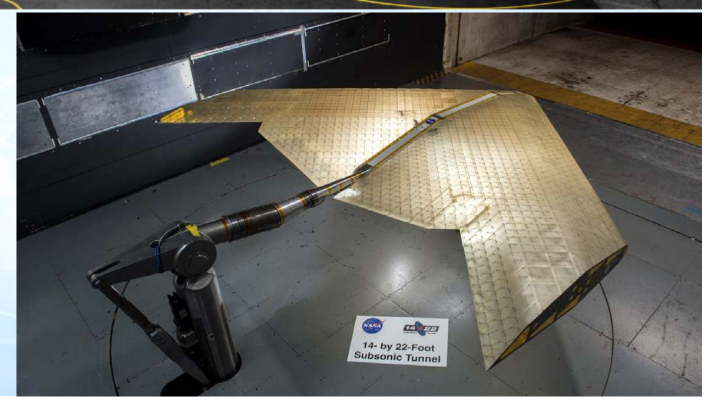


Impact:

- Scalable, cost effective design and manufacturing structures.
- High stiffness-to-density ultra-light aerostructures
- New mission objectives

Results:

- The proposed digital aircraft concept proved to be feasible for achieving aerodynamic performance with variable aerostructure stiffness, which will enable new mission opportunities



Learn to Fly

Objective: Develop Self-Learning Airplane Technologies

- Flight tests of novel configurations with no ground-based testing, with aircraft autonomously developing models and control strategy in flight – updating as it learns more about itself

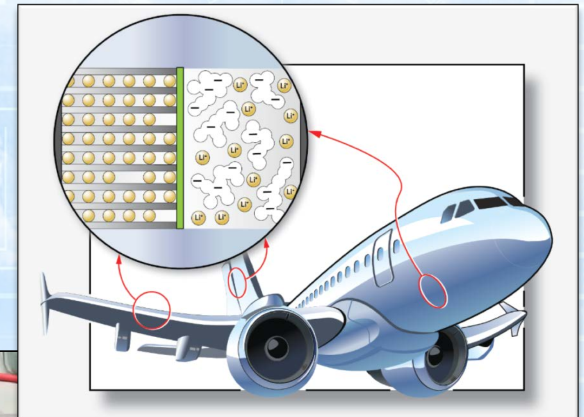
Impact:

- Much lower cost/time for airplane development
- Safety / reliability improvement

Results:

- Modeling: Automated real-time onboard global aerodynamic modeling was successfully demonstrated in flight
- Controls & Mixer: Desired vehicle response adjusted real-time, online based on the vehicle's dynamics
- Guidance: Control system learning enabled vehicle to follow a desired ground track for navigation
    - Vehicle learned best glide performance for landing
    - Repeatable, stabilized approach to landing demonstrated

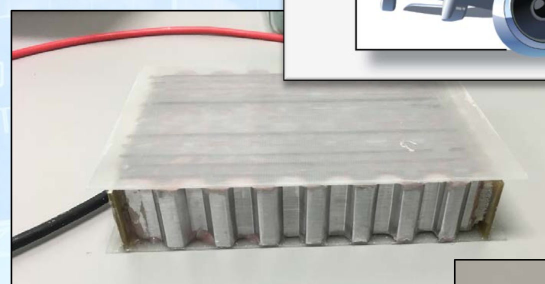
M-SHELLS: Multifunctional Structures for High Energy Lightweight Load-bearing Storage



Objective: Determine the feasibility of **combining structure and energy storage** into one integrated component

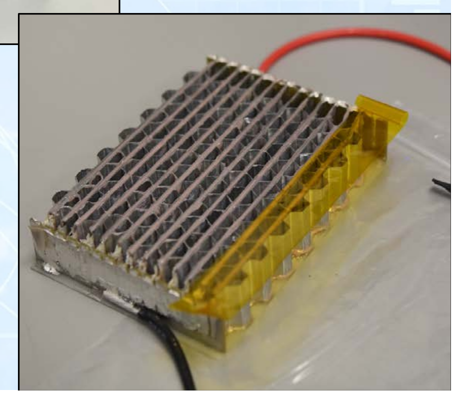
Impact: **Significantly reduces the system level weight and volume** by combining the structural function and energy storage function in one piece

- ✓ Increased range, Increased payload, Increased efficiency



Results:

- Successfully **demonstrated a multifunctional configuration** that can store or deliver power while under mechanical load without electrochemical failure
- Showed **potential weight savings** if M-SHELLS multifunctional material could replace existing structure + batteries

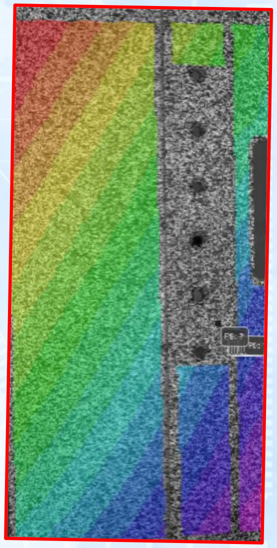


Digital Twin

Objective:
- Expand the design space and accelerate certification of future structural configuration while assuring safety and reliability.

Impact:
- The digital twin concept combines as-build components, as-experienced loads and environmental conditions, and vehicle-specific characteristics to enable ultra-high fidelity models that **can drastically reduce uncertainty and improve predictions of structural performance and service life.**

Results:
- Digital Twin is feasible and could be implemented on the component level
  - Can use a variety of data input from physical twin
  - Can handle and quantify uncertainty in input data
  - Can be improved on the fly by reducing uncertainties (e.g. by upgrading sensors or improving damage model)



Needs improvement