



# Modular Rapidly Manufactured SmallSat: Using Advanced Manufacturing Processes for CubeSats

By: Christopher Hartney, Kenneth Cheung, and Ali Guarneros Luna  
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# Overview

- **Introduction**
- **Digital Materials**
- **Goals and Objectives**
- **Current Designs**
- **Accomplishments to Date**
- **Schedule**
- **Conclusion**



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# Team

## **NASA Ames Research Center**

Ali Guarneros Luna

Kenneth Cheung

Christopher Hartney

Greenfield Trinh

Office of the Chief Technologist

Elwood Agasid

Marc Murbach

## **Massachusetts Institute of Technology**

Center for Bits and Atoms

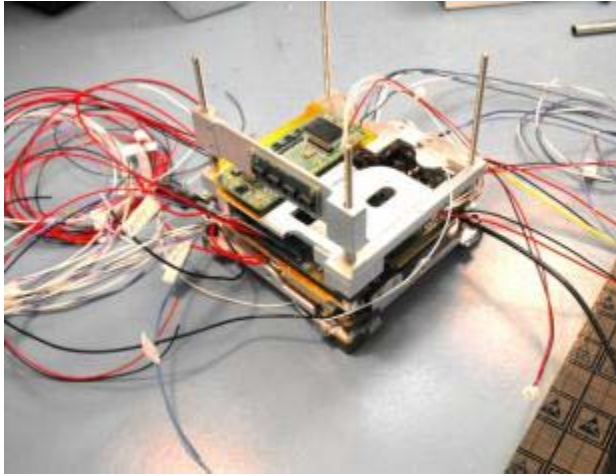
## **Cornell University**

## **San Jose State University**

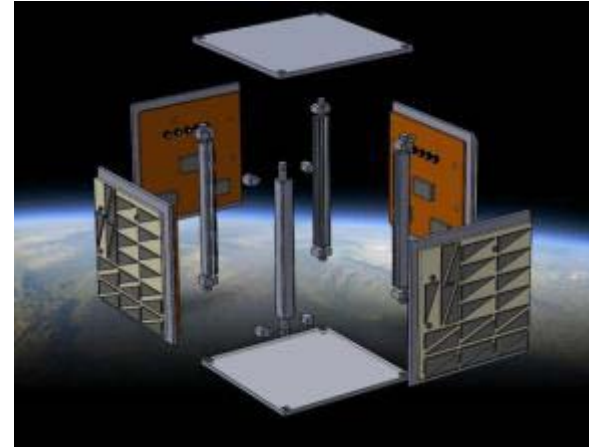
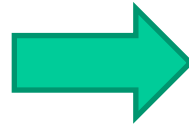




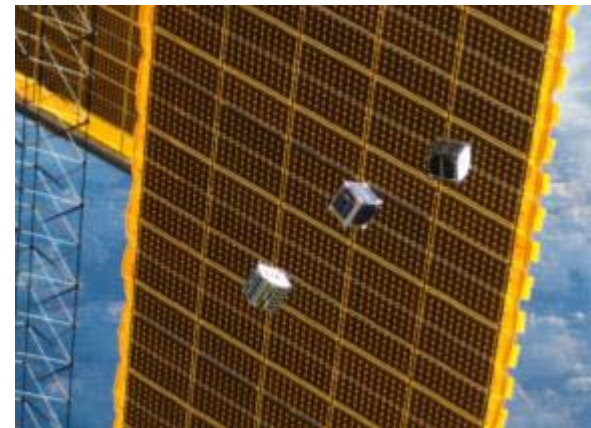
# Introduction



Complex, labor/time intensive



Simple, modular, rapid



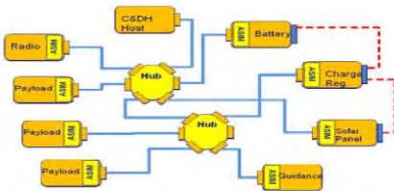
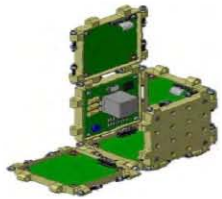


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# Digital Materials

## 1.0 PROJECT OBJECTIVES

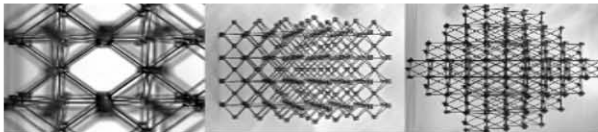
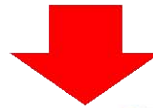


(McNutt ETAL 2009, nano-SPA, AFRL)

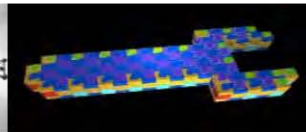


(White ETAL 2011, RAMPART)

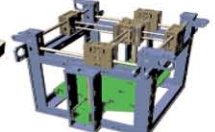
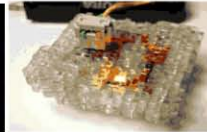
(Lopes ETAL 2012, COSMIAC, AFRL)



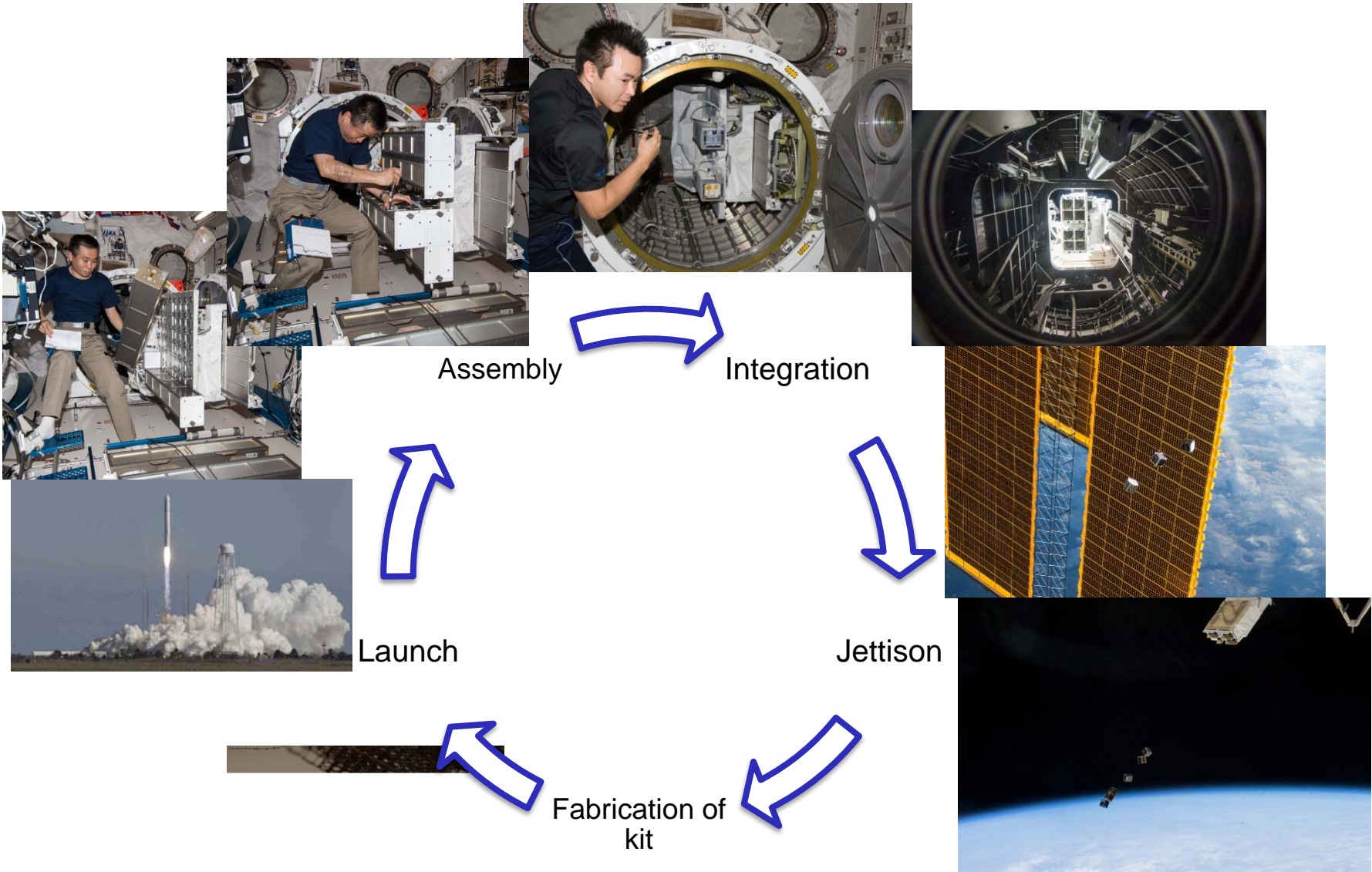
(Cheung ETAL 2013, MIT CBA)



(Ward ETAL 2011, MIT CBA)







# TECHNOLOGY MATURATION STORY

Objective is to bring down the cost, integration and time from start to finish.

Using slide-fit card technology for spacecraft subsystems and components to maximize payload

Looking at low-cost microcontrollers and advanced manufacturing

RJ45 connectors to connect side panels

Looking at advanced communications



## Modular Rapidly Manufactured Nano Sat *design study "clickSat"*

NASA GCD Advanced Manufacturing Technology

"what if we assembled satellites on orbit?"

large interior volume available for payload

assembly on orbit eliminates structural requirements for launch survival, significantly reduces structural mass

single data / power wiring connector per face plate, ends snap in, locking face plates on

face plate pcbs snap in to rails

launch package "flat packed"

assembled sat ready for deployment

ARC kenny@nasa.gov 2014

## Modular Rapidly Manufactured Nano Sat *design study "tentSat"*

NASA GCD Advanced Manufacturing Technology

"what if we assembled satellites on orbit?"

chassis pops up using elastic energy of shock cords, as 3D tent poles

single data / power wiring connector per face

face plates containing avionics snap in to rails

launch package "flat packed"

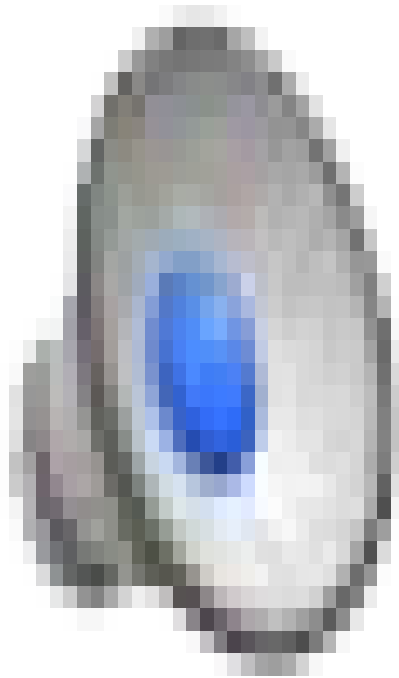
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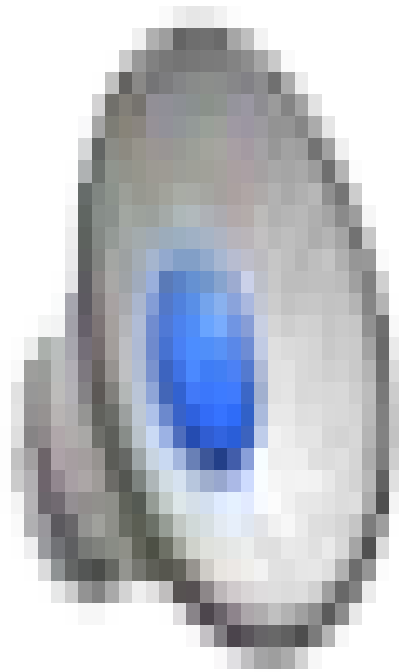
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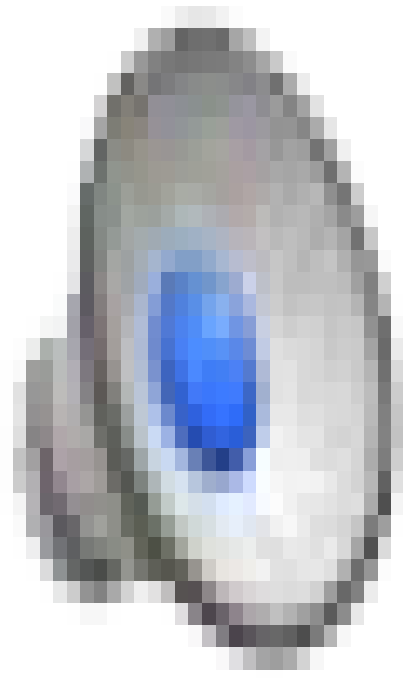


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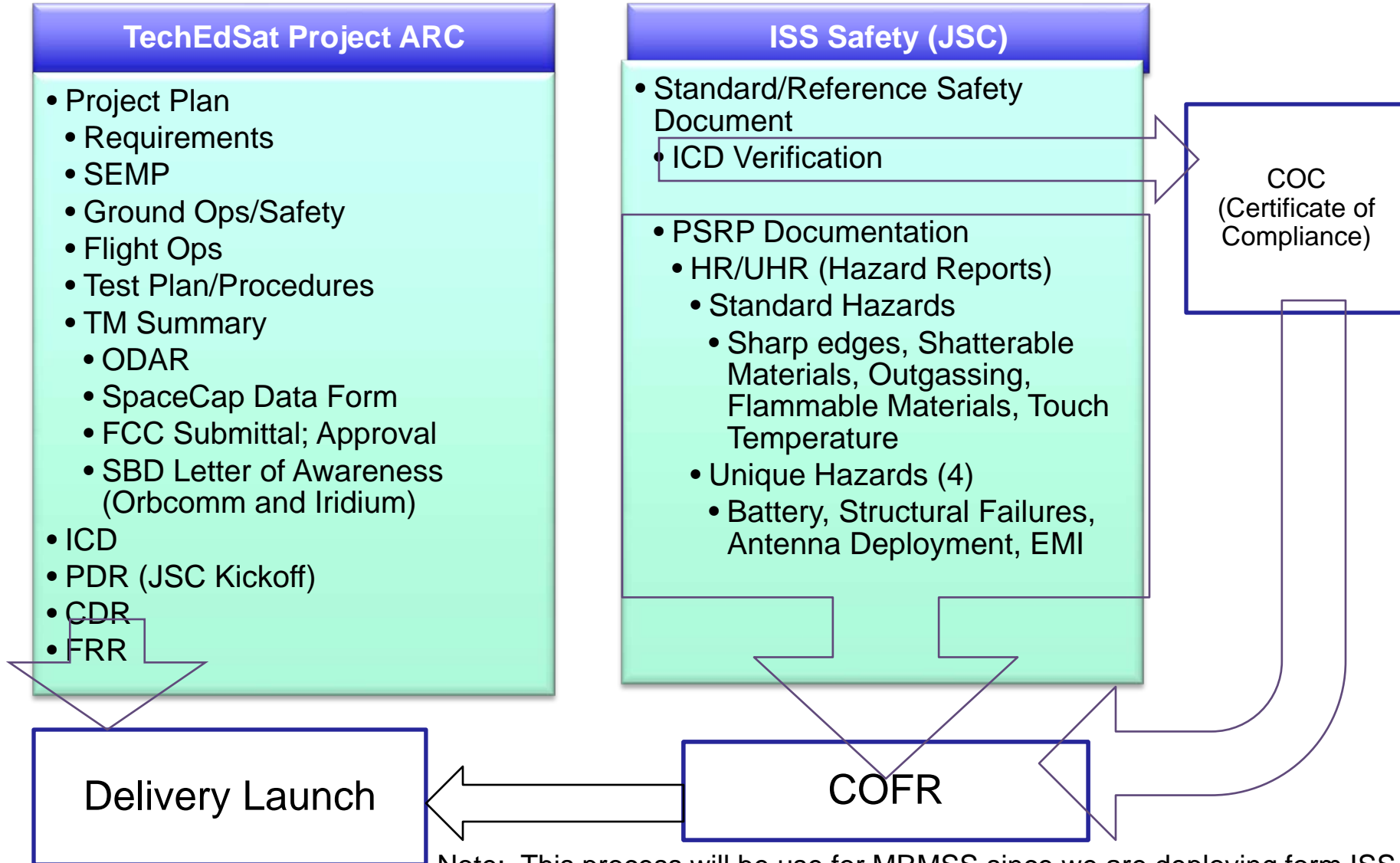
# Ames

Discovery ◊ Innovations ◊ Solutions





## TechEdSat Document Tree/ Process



Note: This process will be use for MRMSS since we are deploying form ISS





# FY14 Accomplishments To Date

## FY14 Accomplishments:

Possible prototypes of designs are being built

Talked to JSC for possible material and design selections

Destructive testing for connections addressing Human Factors

Established conversation with Launch Vehicle Service Provider

Established collaboration with TechEdSat team for Communication system

- **PM/IP are being successful in deploying cubesat from ISS using different communication Systems**

## Technology Firsts

Will demonstrate the rapidly fabricated, modular and integrated small satellite systems in the International Space Station using the advanced manufacturing technologies, techniques and materials



Element	Milestone	Date	Description
FY14	Project Kickoff	November 15, 2013	
	Status Review 1	April 4, 2014	Review of project development
	Status Review 2	July 18, 2014	Project design review and development
	Close-out / Transition Review	September 30, 2014	The Final review of the research project development and transition to SSTP
FY15	Technical Interchange Meeting (TIM) meeting with ISS PSRP	Nov-14	Presentation to Safety Panel at JSC
	PSRP 0/I	Jan-15	Review of project and safety by the safety panel
	PSRP II	Mar-15	Review of project and safety by the safety panel
	PSRP III	May-15	Review of project and safety by the safety panel
	On Dock date	Jun-15	Product deliver to NanoRacks or JAXA for intergartion to softstow bag
	Launch to ISS	Jul-15	On launch Vehicle
	Assemble in ISS	Aug-15	Astronauts assemble cubesat in ISS
	jettison from ISS	Sep-14	Cubesat get integrate on Deployer and jettison from ISS
	Operation in space	~ 300 day after deployment	Functional and operational cubesat on space



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## Summary

- **MRMSS will utilize Modular “Digital Material” technology for spacecraft subsystems and components to maximize payload volume**
- **Adding assembly capability to the ISS for cubesats**
- **Numerous Technologies Advanced**
  - Manufacturing
  - Fabrication
  - Assembly
- **Future Work leads to Developing advanced manufacturing technologies that enable the development of more capable and lower-cost space missions and launch vehicles.**