Nondestructive Evaluation Education, Experiences and Career at NASA

Brazosport College

August 2017

Part 1

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ASNT Level III (UT,RT, ET, PT, MT)
NDE Lead Engineer
NASA Johnson Space Center
Agenda

- Education and Experiences
- Publications/Patents
- NASA Programs with NDE Involvement

Contains information that is publically available on the internet
Publications/Patents

– Areas
  • Ultrasonic stress/preload measurements: Modeling and measurement
  • Residual stress measurement
  • Thermal NDE, Temperature measurement: modeling, analysis, measurement, data processing
  • Eddy current flaw detection
  • Computed Tomography: POD Analysis
  • POD data analysis
  • X-ray Flaw detection: Modeling and analysis

– Publication Sites

– U.S. Patent
  • Thermal NDE, two patents for NASA
  • Citation in Patent: 1 (used by Boeing for bolt assembly of critical joints on commercial planes)
| 1 | Preload measurement in sleeve bolts using an ultrasonic technique, A Koshti - Materials evaluation, 1996 - proceedings.spiedigitallibrary.org |
| 2 | Effect of bending on ultrasonic preload measurements in bolts, AM Koshti - on NDE for Health Monitoring and ..., 2001 - proceedings.spiedigitallibrary.org |
| 3 | Simulation of ultrasonic measurement on a bolt in a shear joint, Proc. SPIE 4702, A M Koshti, Smart Nondestructive Evaluation for Health Monitoring of Structural and Biological Systems, 411 (June 11, 2002); doi:10.1117/12.469903 |
| 5 | Simulation of ultrasonic preload measurement on a bolt in an interference fit joint, A M Koshti - NDE For Health Monitoring and ..., 2002 - proceedings.spiedigitallibrary.org |
| 7 | Ultrasonic measurement of the bending of a bolt in a shear joint, A M Koshti - Experimental mechanics, 1998 - Springer |
| 8 | Stress measurement via the acoustoelastic effect and water-coupled ultrasonic waves, A M Koshti, D M Egle - NDT and E International, 1995 - ingentaconnect.com |
| 14 | An Alternate Technique for Implementing Center-Hole Drilling/Residual-Stress Measurements A M KOSHTI, D M EGLE - Experimental Techniques, 1985 - Wiley Online Library |
Internet Sites with Profile and Publications

http://spie.org/profile/Ajay.Koshti-153499
https://www.linkedin.com/
http://scholar.google.com/

Contains information that is publicly available on the internet
Education and Experience

1974-1976: Junior College, University of Bombay (Mumbai)
1976-1981: Bachelor of Technology (Mechanical Engineering)
           Indian Institute of Technology, Bombay
1981-1982: Union Carbide India Ltd. (Bombay)
           Maintenance Engineer
1983-1985: M.S. (Mechanical Engineering)
           University of Oklahoma
1985-1987: Pace Setter Inc. Manufacturing Engineer
           ASNT Level III (UT)
1988-1993: Rockwell International, Downey, CA
           NDE/Quality Engineer, Space Shuttle Orbiter Program
           ASNT Level III (PT, MT, RT, ET)
           PE (Mechanical Engineering)
1993-2003: Rockwell International and Boeing North American
           Kennedy Space Center
           NDE, Ground Support Engineering and Orbiter Handling Engineering
2002:    Doctor of Science in Mechanical Engineering, University of Mumbai
2004-Current: NASA Johnson Space Center
           Lead NDE Engineer
University of Mumbai (Bombay)

Established 1857
Established by British Rulers in India

University is Ranked 5th in India

Contains information that is publically available on the internet
Indian Institute of Technology, Bombay

Established in 1958
Ranked 39th in Asia
IIT Undergraduate Brand is Recognized worldwide
as IIT Engineers have emigrated to most developed countries and done very well.

Main Building
Sports Field
Mechanical Eng. Side View
Mechanical Eng. Entrance

Contains information that is publically available on the internet
University of Oklahoma

Well known in College Football
7 national championships,
44 conference championships
#88 in Mechanical Eng. by U.S. News

Contains information that is publically available on the internet
Space Shuttle Program
Rockwell Intl., Downey and Palmdale CA

Space Shuttle
First flight April 12, 1981

Last flight July 21, 2011

Worked in Downey plant from 1988 to 1993

Contains information that is publicly available on the internet
Kennedy Space Center
Space Shuttle Launch Pad & VAB Area

Space Shuttle Orbiter Towlines
Designed by Ajay Koshti

Google Map of Vehicle Assembly Building Area
Worked at Kennedy Space Center for Boeing from 1993 to 2003
Ultrasonic Preload Measurement Applications

Case 1: Clamp Joint (Shank in Clearance)
- Measure bolt preload

Case 2: Double Shear Joint
- Measure Load P

Case 3: Flange Joint
- Measure bolt preload

Case 4: Clamp Joint with Interference
- Ultrasonic transducer contacts on bolt head or tail
- Measures ultrasonic wave return trip
- transit time through the length of the bolt

See papers 1 through 7 by Ajay Koshti for applications of four cases. Covers modeling and experimental results.
Space Shuttle Ultrasonic Preload Applications

Three bolt (0.7” Dia) locations in a Flange Joint in the 17” Orbiter/ET Disconnect

Led development of above ultrasonic preload applications.

Two 2” Dia. Orbiter to Aircraft attachment bolts in Clamped Joint

Two Vertical Tail attachment sleeve bolts in Interference Joint

Contains information that is publically available on the internet
Vehicle Assembly Building

Contains information that is publically available on the internet
Tailcone is the only hardware built by Boeing before acquiring Rockwell Aerospace and McDonnell Douglas. Tailcone was used for a ferry flight atop Boeing 747.
NASA Johnson Space Center

Robonaut R2 above ISS
Currently ISS is the largest program for NASA Johnson space Center
International Space Station

Station statistics

- **COSPAR ID**: 1998-067A
- **Call sign**: Alpha
- **Crew**: Fully crewed 6
  - Currently aboard 6
  - (Expedition 38)
- **Launch**: 1998
- **Launch pad**: Baikonur 1/5 and 81/23
  - Kennedy LC-39
- **Mass**: approximately 450,000 kg (990,000 lb)
- **Length**: 72.8 m (239 ft)
- **Width**: 108.5 m (356 ft)
- **Height**: c. 20 m (c. 66 ft)
  - nadir–zenith, arrays forward–aft
  - (27 November 2009) [latter info]
- **Pressurised volume**: 837 m³ (29,600 cu ft)
  - (21 March 2011)
- **Atmospheric pressure**: 101.3 kPa (29.91 inHg, 1 atm)
- **Perigee**: 417 km (259 mi) AMSL
- **Apogee**: 422 km (262 mi) AMSL
- **Orbital inclination**: 51.65 degrees
- **Average speed**: 7.66 kilometres per second (27,600 km/h; 17,100 mph)
- **Orbital period**: 92.83 minutes
- **Orbit epoch**: 8 March 2014
- **Days in orbit**: 5587
  - (8 March)
- **Days occupied**: 4874
  - (8 March)
- **Number of orbits**: 8756
- **Orbital decay**: 2 km/month

Statistics as of 9 March 2011

Contains information that is publically available on the internet.
NASA Ellington Field, Houston

Contains information that is publically available on the internet
## Project Morpheus

<table>
<thead>
<tr>
<th>USA</th>
<th>NASA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designer</td>
<td>NASA</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>NASA/JSC</td>
</tr>
<tr>
<td>Application</td>
<td>Planetary and lunar lander</td>
</tr>
<tr>
<td>Status</td>
<td>In development</td>
</tr>
</tbody>
</table>

**Liquid-fuel engine**

**Propellant**  
- liquid oxygen / methane \(^1\)

**Performance**

- **Thrust**: 22000 N \(^2\)
- **Specific impulse**: 321 s \(^3\)
- **Burn time**: tested: 123 s \(^4\)

**Used in**
- Morpheus Lander

Contains information that is publically available on the internet
Astronaut Suits

Mark III Suit

ISS EMU Suit

Contains information that is publically available on the internet
NASA Simplified Aid for EVA Rescue (SAFER)
The **Orion Multi-Purpose Crew Vehicle (Orion MPCV)** is an American spacecraft intended to carry a crew of four astronauts to destinations at or beyond low Earth orbit (LEO). Currently under development by **NASA** for launch on the **Space Launch System**, Orion is intended to facilitate human exploration of **asteroids** and of **Mars** and to retrieve crew or supplies from the **ISS** if needed.

The MPCV's first test flight (uncrewed), known as **Exploration Flight Test 1** (EFT-1), was launched atop a **Delta IV Heavy** rocket on December 5, 2014, on a flight lasting 4 hours and 24 minutes, landing at its target in the **Pacific Ocean** at 10:29 Central. The first mission to carry astronauts is not expected to take place until 2023 at the earliest, although NASA officials have said that their staff is working toward an "aggressive internal goal" of 2021.
**NASA Orion Spacecraft**

**Description**

**Role:**
Beyond LEO, back-up for commercial cargo and crew to the ISS [1]

**Crew:**
2–6 [2]

**Carrier rocket:**
Space Launch System (planned-deep space), Delta IV (test flight), Ares I (cancelled)

**Launch date:**
December 5, 2014 (uncrewed test launch) [3]

**Dimensions**

**Height:**
5 m (16.5 ft.)

**Diameter:**
5 m (16.5 ft.)

**Pressurized volume:**
19.56 m³ (691 cu ft) [4]

**Habitable volume:**
8.95 m³ (316 cu ft) [4]

**Capsule mass:**
8,913 kg (19,650 lb.)

**Service Module mass:**
12,337 kg (27,198 lb.)

**Total mass:**
21,250 kg (46,848 lb.)

**Service Module propellant mass:**
7,907 kg (17,433 lb.)

**Performance**

**Total delta-v:**
1,595 m/s

**Endurance:**
21.1 days [2][4]

Contains information that is publicly available on the internet.
Orion Spacecraft

• NASA’s Orion spacecraft will carry astronauts further into space than ever before using a module based on Europe’s Automated Transfer Vehicles (ATV).

• The ATV-derived service module, sitting directly below Orion’s crew capsule, will provide propulsion, power, thermal control, as well as supplying water and gas to the astronauts in the habitable module.

• The first Orion mission will be an uncrewed lunar flyby in 2018, returning to Earth’s atmosphere at 11 km/s – the fastest reentry ever.
Engineers successfully tested the parachutes for NASA's Orion spacecraft at the U.S. Army Yuma Proving Ground in Arizona Wednesday, March 8, 2017.
Orion Spacecraft

Assembly operation to prepare Orion EFT 1 for its first flight in December 2014.

Orion Lifting off on top of a Delta IV Heavy on December 5, 2014
Space Launch System (SLS)

- The Space Launch System (SLS) is an American Space Shuttle-derived heavy expendable launch vehicle being designed by NASA. It is to replace the retired Space Shuttle. The SLS will be the most powerful rocket ever built, with about 20% more thrust than the Saturn V and a comparable payload capacity, putting the SLS into the super heavy-lift launch vehicle class of rockets.

- The SLS launch vehicle is to be upgraded over time with more powerful versions. Its initial Block 1 version is to lift a payload of 70 metric tons to low Earth orbit (LEO), which will be increased with the debut of Block 1B and the Exploration Upper Stage.

- Block 2 will replace the initial Shuttle-derived boosters with advanced boosters and is planned to have a LEO capability of more than 130 metric tons to meet the congressional requirement. These upgrades will allow the SLS to lift astronauts and hardware to various beyond-LEO destinations: on a circumlunar trajectory as part of Exploration Mission 1 with Block 1, to a near-Earth asteroid in Exploration Mission 2 with Block 1B, and to Mars with Block 2. The SLS will launch the Orion Crew and Service Module and may support trips to the International Space Station if necessary. SLS will use the ground operations and launch facilities at NASA's Kennedy Space Center, Florida.
NASA Commercial Crew

Boeing CST 100

SpaceX Dragon with Falcon 9 Launch Vehicle

Sierra Nevada Dream Chaser with Atlas

Contains information that is publically available on the internet
**SpaceX Dragon Spacecraft**

- **Dragon** is a spacecraft developed by SpaceX, an American private space transportation company based in Hawthorne, California. Dragon is launched into space by the SpaceX Falcon 9 two-stage-to-orbit launch vehicle, and SpaceX is developing a crewed version called the Dragon 2.

- During its maiden flight in December 2010, Dragon became the first commercially built and operated spacecraft to be recovered successfully from orbit. On 25 May 2012, a cargo variant of Dragon became the first commercial spacecraft to successfully rendezvous with and attach to the International Space Station (ISS). SpaceX is contracted to deliver cargo to the ISS under NASA's Commercial Resupply Services program, and Dragon began regular cargo flights in October 2012. With the Dragon spacecraft and the Orbital ATK Cygnus, NASA seeks to increase its partnerships with domestic commercial aviation and aeronautics industry.

Contains information that is publically available on the internet
Dragon 2 Manned Spacecraft

Dragon 2 spacecraft conducting a propulsive hover test, Nov. 2015

Crew Dragon Pad Abort Test Launch, May 6, 2015

An infographic of the SpaceX Dragon 2 Pad Abort Test for the May 2015 test, produced by SpaceX
The **Falcon rocket family** is an American family of multi-use rocket launch vehicles developed and operated by Space Exploration Technologies (**SpaceX**). The vehicles in this family include the flight-tested **Falcon 1** and **Falcon 9**. The Falcon 1 made its first successful flight on 28 September 2008, after several failures on the initial attempts. The larger **Evolved Expendable Launch Vehicle** (EELV)-class Falcon 9 flew successfully into orbit on its maiden launch on 4 June 2010. The Falcon 9 is eventually intended to be a reusable vehicle. SpaceX is currently in production of the first **Falcon Heavy** launch system. Other designs for boosters with even larger payload lifting capabilities are currently being researched, but not yet confirmed.

Contains information that is publically available on the internet
SpaceX Falcon

Falcon 9 first stage on an ASDS barge after the first successful landing at sea, CRS-8 Mission. April 2016

Contains information that is publically available on the internet
# Boeing CST-100 Starliner

## General information

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Boeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country of origin</td>
<td>United States</td>
</tr>
<tr>
<td>Applications</td>
<td>Crew Transfer Vehicle</td>
</tr>
<tr>
<td>Orbit regimes</td>
<td>Low Earth</td>
</tr>
<tr>
<td>Operator</td>
<td>Boeing, Bigelow Aerospace</td>
</tr>
<tr>
<td>Lifetime</td>
<td>210 days (docked to ISS)</td>
</tr>
</tbody>
</table>

## Production

| Status            | In development |

## Typical spacecraft

| Average mass      | ≈10 tonnes[1] |
| Power             | 4 x 26300 Kg[1][clarification needed] |

## Dimensions

| Dimensions         | 4.56 m |
|                   | CM+SM: 5.03 m |
|                   | CM: 3.14 m[1] |

Contains information that is publically available on the internet
NASA Commercial Crew: Dream Chaser by Sierra Nevada

Description

Role: Part of NASA's Commercial Crew Program to supply crew and cargo to the International Space Station

Crew: Up to 7

Dimensions

<table>
<thead>
<tr>
<th>Length</th>
<th>9.0 m</th>
<th>29.5 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing Span</td>
<td>7.0 m</td>
<td>22.9 ft.</td>
</tr>
<tr>
<td>Volume</td>
<td>16.0 m³</td>
<td>565 cu ft.</td>
</tr>
<tr>
<td>Mass</td>
<td>11,300 kg</td>
<td>25,000 lb.</td>
</tr>
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Performance

Endurance: At least 210 days

Re-entry: Less than 1.5

Size Comparison to Space Shuttle

Contains information that is publically available on the internet
Bigelow Expandable Activity Module

Full-scale mock-up of BEAM, January 16, 2013

Station statistics

Launch date: 2015
Launch vehicle: Falcon 9
Mass: 3,000 lb (1,360 kg)[1]
Length: 13 ft. (4 m)[1]
Diameter: 10.5 ft. (3.2 m)[1]
Living volume: 565 cu ft (16 m³)[2]

Contains information that is publically available on the internet
Blue Origin

Incremental Development

- **Suborbital program in flight testing stage**
  - Goddard subscale demonstrator flown 2006-2007
  - New Shepard system in development
    - Propulsion Module
      - 2011 testing demonstrated boost, landing and flight to 45,000 feet/Mach 1.2
      - Development of next vehicle underway
    - Crew Capsule – successful pad escape test October 2012

- **Orbital Transportation System**
  - Reusable orbital Space Vehicle (SV)
    - Transport to LEO or ISS for up to seven people
    - ~22,000 lbm with crew at launch
  - Two-stage Orbital Launch Vehicle (OLV)
    - Expendable upper stage
    - Reusable first stage
Blue Origin

New Shepard Launch on April 29, 2015.

New Shepard landing with parachutes on April 29, 2015.