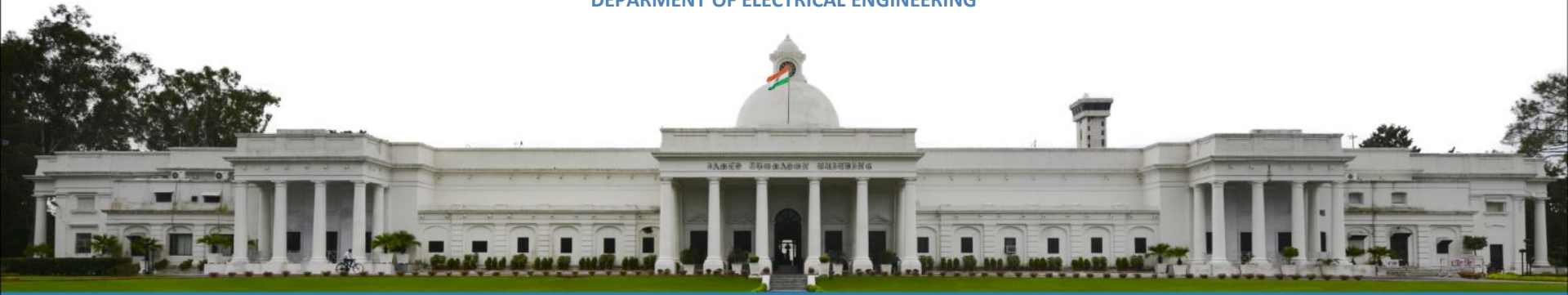
IIT ROORKEE

NPTEL ONLINE
CERTIFICATION COURSE

Prof. FELIX ORLANDO MARIA JOSEPH

DEPARMENT OF ELECTRICAL ENGINEERING



Robot Assisted Percutaneous Interventions

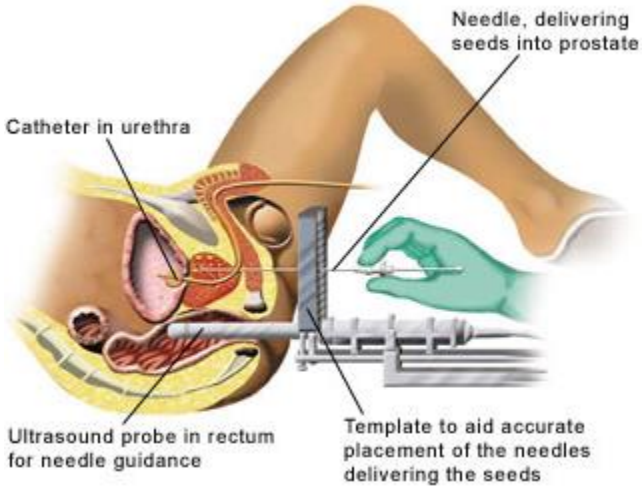
Outline

1. Introduction
   - Why Robotic Assistance?
2. Functional Requirements
3. Basic Workflow
4. Current Robotic Systems
5. Conclusion

Introduction

Why Robotic Assistance ?

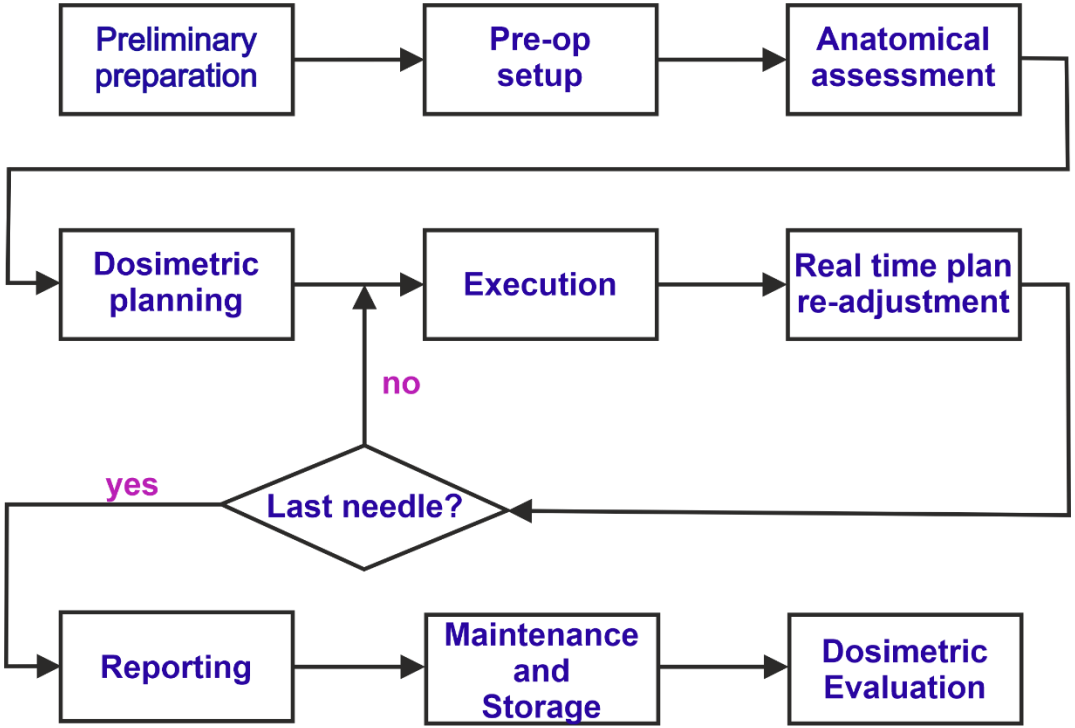
- To improve the **needle tip positioning and seed delivery accuracies**
- **Reduce radiation exposure & fatigue of physician**
- **Dose Optimization**



Functional Requirements

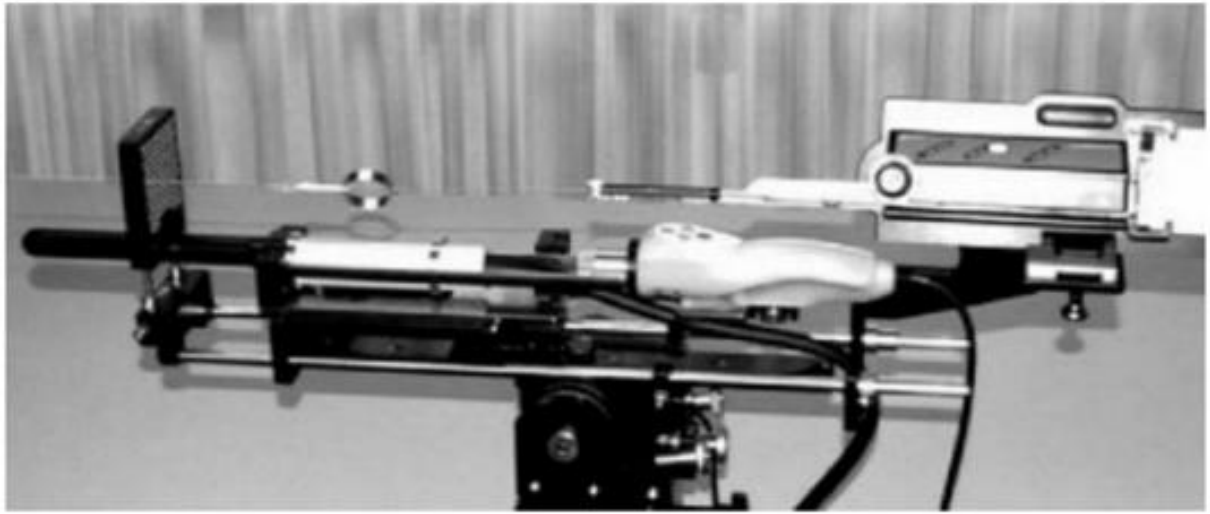
- Safety
- Ease in Decontamination
- Force and Visual Feedback
- Compact, Reliable and Robust operation
- Anytime provision for conventional mode

Robotic System Clinical Workflow



Current Robotic Systems

Elektra-Nucletron FIRST system

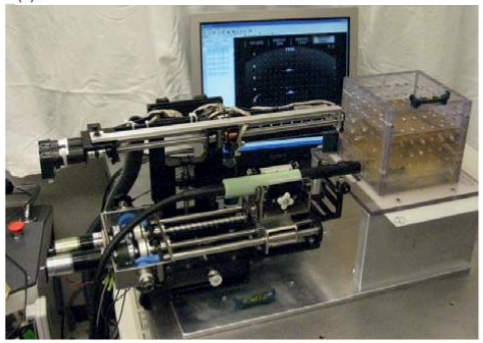


- DOF: **2**
- Number of Needle: **1**
- Needle Insertion: **Manual**
- TPS: **Oncentra Seeds**
- Needle-tip positioning accuracy: **<0.5mm**
- Seed deposition accuracy: **<1mm**
- FDA approved: **Yes**

Ref: M J Rivard et al "A technical evaluation of the Nucletron FIRST system: Conformance of a remote after loading brachytherapy seed implantation system to manufacturer specifications and AAPM Task Group report recommendations"J. Appl.Clin.Med.Phys. 6,22-50(2005)

Current Robotic Systems (cont'd)

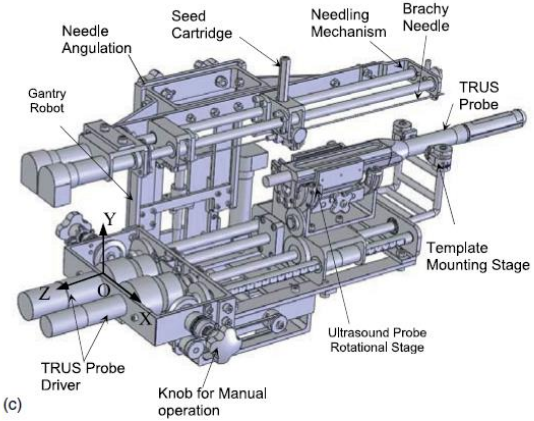
(a)



(b)

EUCLIDIAN(TJU)-An ultrasound image-guided prostate brachytherapy system

Ref: Podder et al Report of Task Group 192

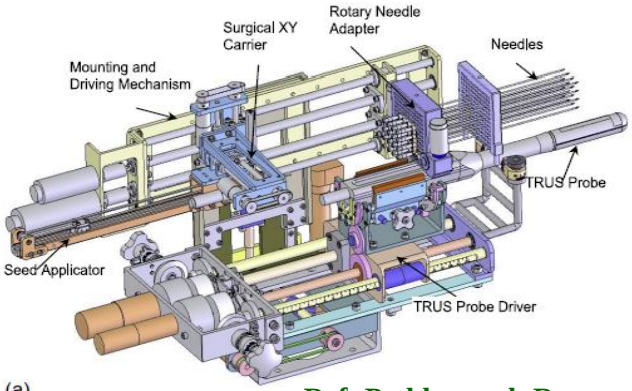


(c)

- DOF: **5 DOF surgical; 2 DOF U/S, 6 DOF positioning, 3 DOF cart**
- Number of Needle: **1**
- Needle Insertion: **Autonomous**
- TPS: **In-house**
- Needle-tip positioning accuracy: **<0.5mm**
- Seed deposition accuracy: **<1mm**
- Force-torque sensor: **Yes**

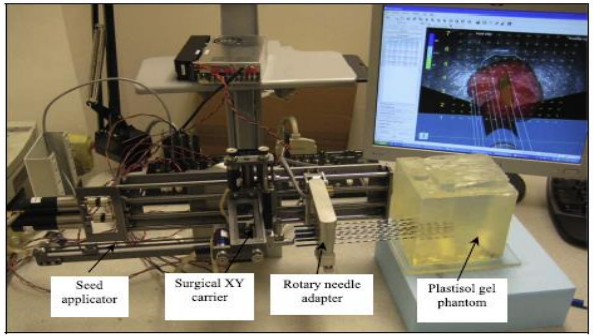
Current Robotic Systems (cont'd)

MIRAB (TJU)-An ultrasound image-guided prostate brachytherapy system



(a)

Ref: Podder et al: Report of Task Group 192

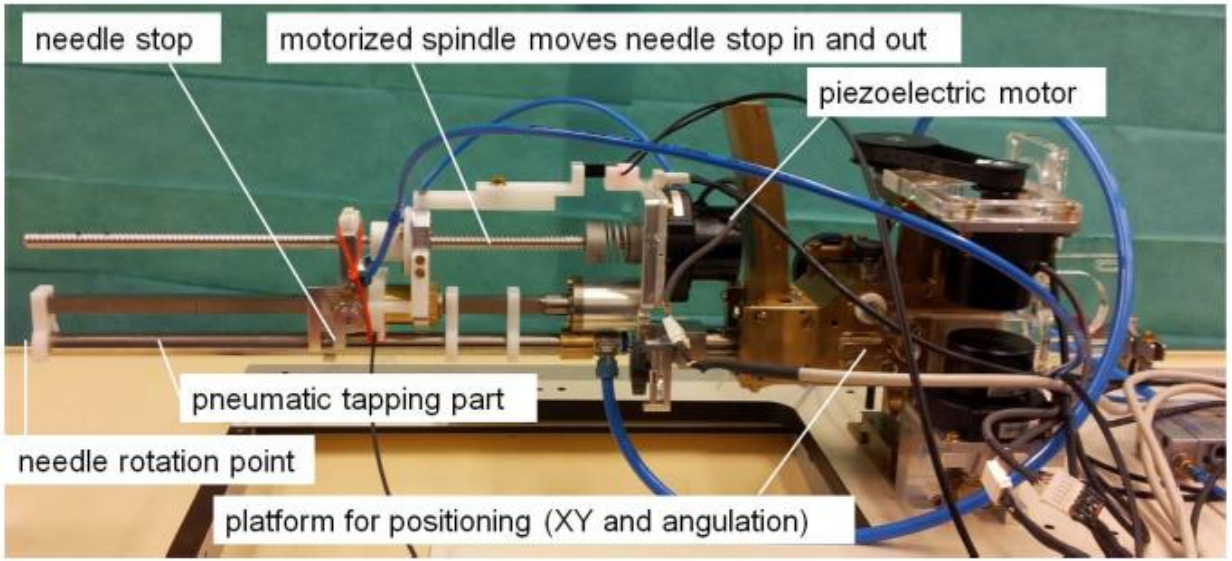


(b)

- DOF: **5 DOF surgical; 2 DOF U/S, 6 DOF positioning, 3 DOF cart**
- Number of Needle: **Multiple**
- Needle Insertion: **Autonomous**
- TPS: **In-house**
- Needle-tip positioning accuracy: **<0.5mm**
- Seed deposition accuracy: **<1mm**
- Force-torque sensor: **No**

Current Robotic Systems (cont'd)

UMCU robot: MRI guided prostate brachytherapy system

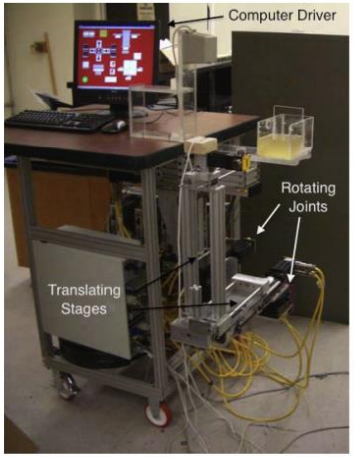


- DOF: **5 DOF**
- Number of Needle: **single**
- Needle Insertion: **Autonomous**
- Needle Withdraw: Manual
- Emergency Stop: **Yes**
- Seed deposition accuracy: **<1mm**
- Force-torque sensor: **No**
- Depth Movement: **150 mm**

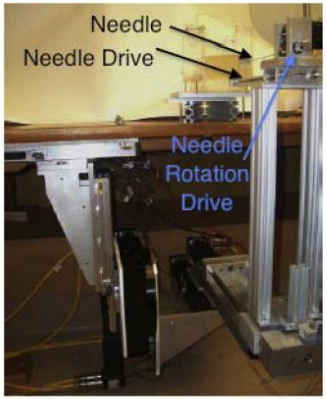
Ref: Podder et al Report of Task Group 192

Current Robotic Systems (cont'd)

UW robot



(a)



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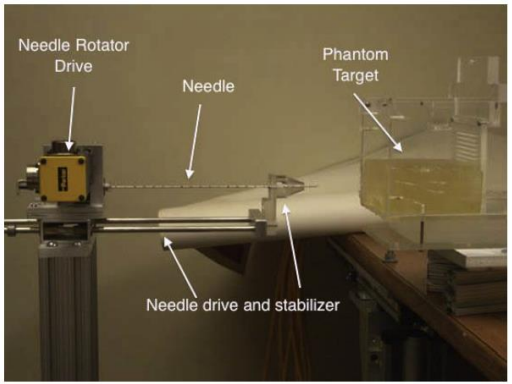


(c)

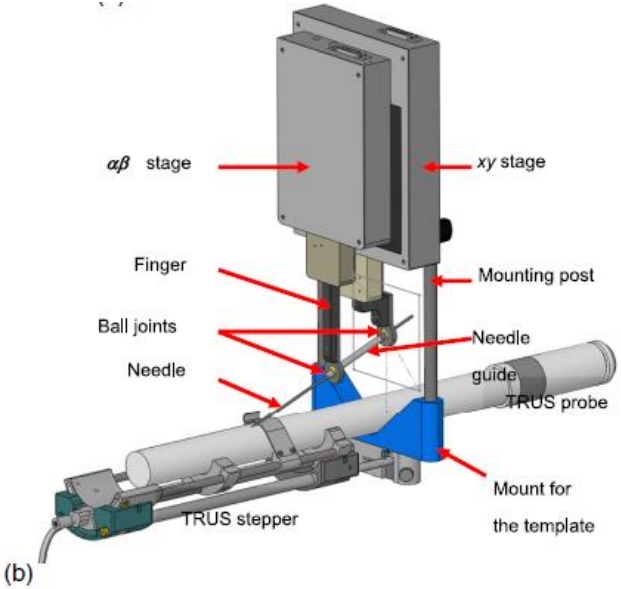
Ref: Podder et al Report of Task Group 192

- DOF: **6 DOF**
- Number of Needle: **Single**
- Needle Insertion: **Autonomous/Manual**
- Needle Withdraw: **Autonomous/Manual**
- Seed deposition accuracy: **<1mm**
- FDA approval: **No**
- Force-torque sensor: **Yes**
- Depth Movement: **250 mm**

Current Robotic Systems (cont'd)

JHU1 robot

(a)



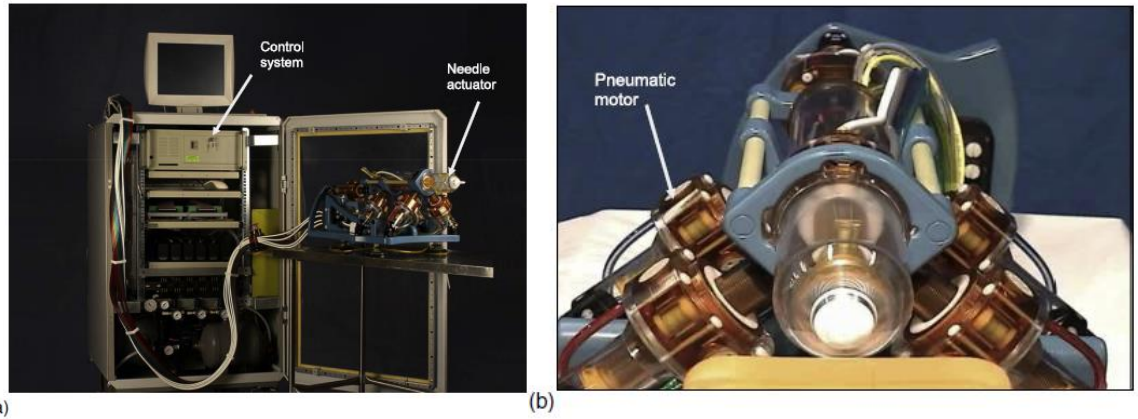
(b)

Ref: Podder et al Report of Task Group 192

- DOF: **4 DOF Surgical**
- Number of Needle: **Single**
- Needle Insertion: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **<1.04mm**
- FDA approval: **No**
- Force-torque sensor: **No**
- Depth Movement: **120 mm**

Current Robotic Systems (cont'd)

JHU2 robot

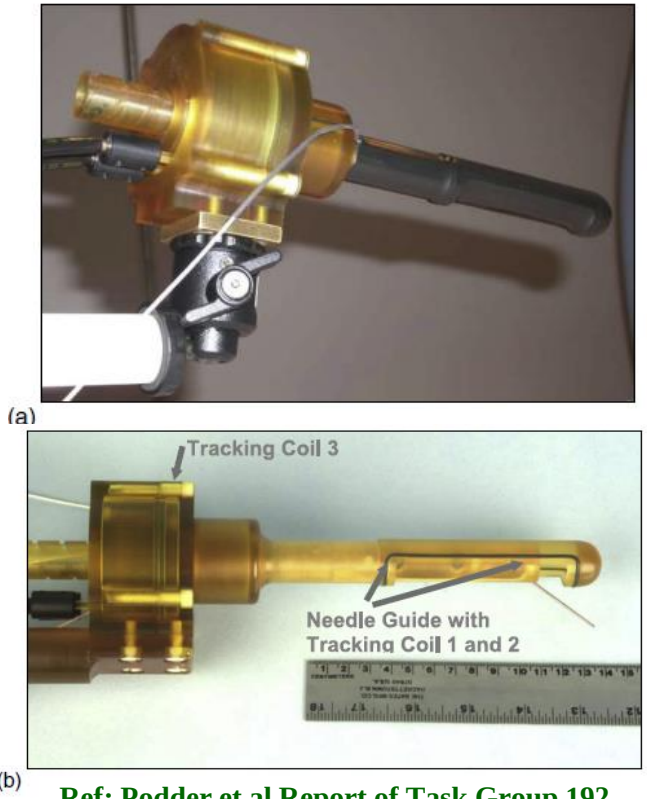


Ref: Podder et al Report of Task Group 192

- DOF: **4 DOF**
- Number of Needle: **Single**
- Needle Insertion: **Autonomous**
- Needle Withdraw: **Autonomous**
- Needle-tip positioning accuracy: **<0.5 mm**
- Seed deposition accuracy: **<1mm**
- Force-torque sensor: **No**
- Depth Movement: **40 mm**

Current Robotic Systems (cont'd)

JHU3 robot

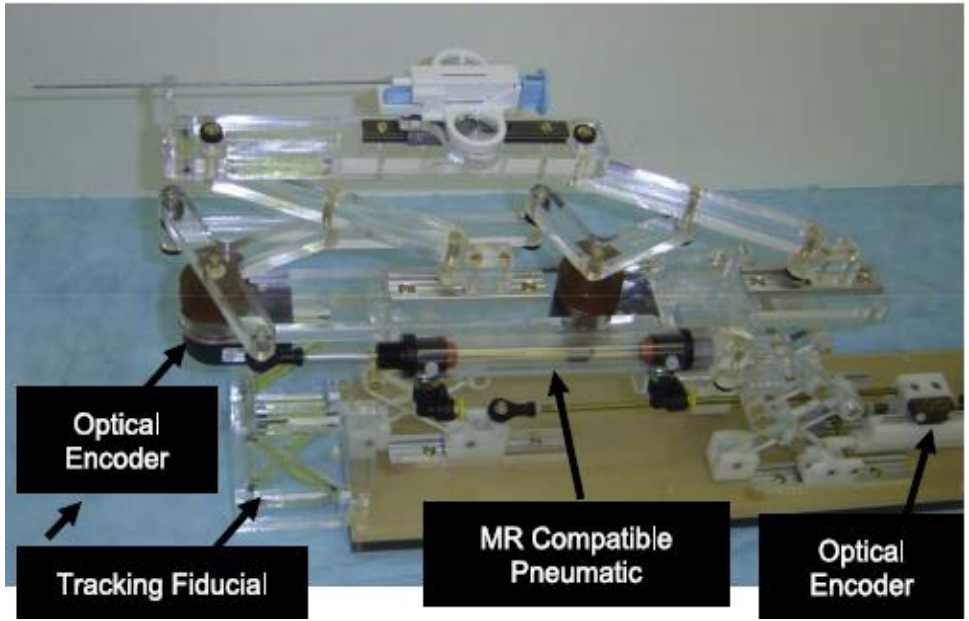


Ref: Podder et al Report of Task Group 192

- DOF: **3 DOF**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **2 mm**
- Provision for conventional mode: **Yes**
- Force-torque sensor: **No**
- Application: **PSI**
- Imaging Modality: **MR**

Current Robotic Systems (cont'd)

JHU and BWH robot

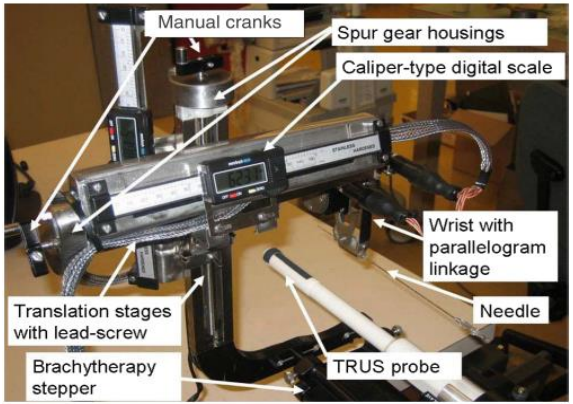


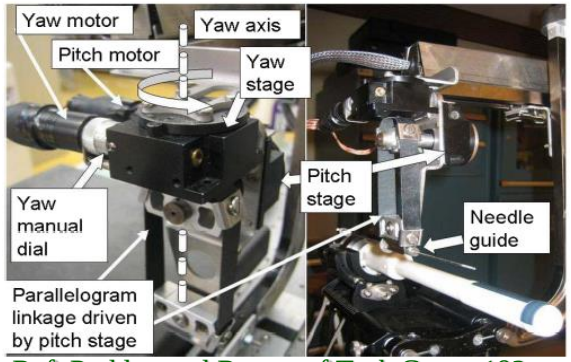
- DOF: **6 DOF**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **3 mm**
- Provision for conventional mode: **Yes**
- Force-torque sensor: **No**
- Application: **PSI**

Ref: Podder et al Report of Task Group 192

Current Robotic Systems (cont'd)

UBC robot



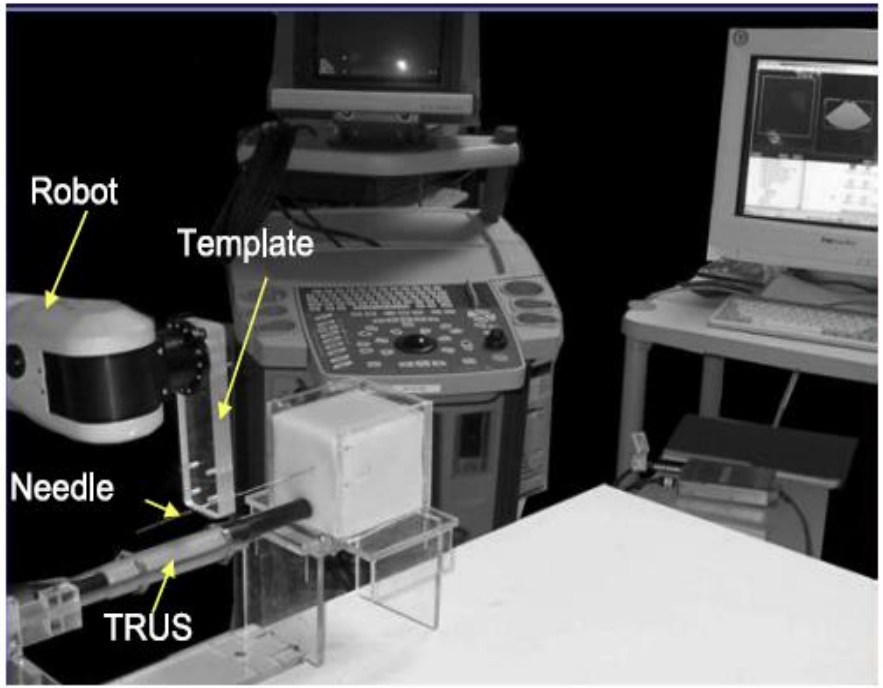


Ref: Podder et al Report of Task Group 192

- DOF: **4 DOF Surgical**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **<0.3 mm**
- Provision for conventional mode: **Yes**
- Imaging Modality: **U/S**
- Application: **PSI**

Current Robotic Systems (cont'd)

RRI robot

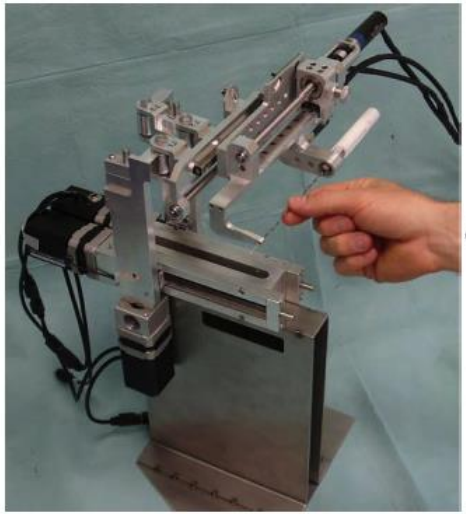


Ref: Podder et al Report of Task Group 192

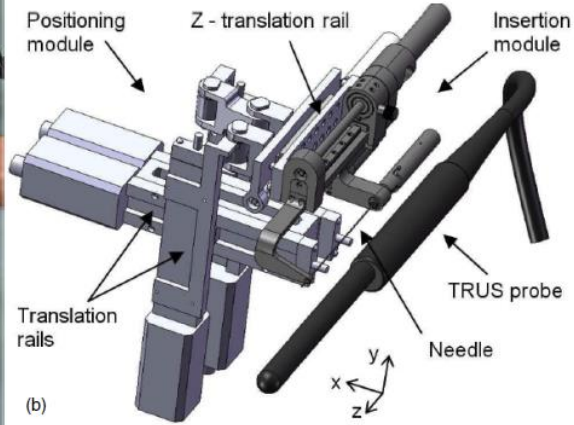
- DOF: **4 DOF Surgical**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **0.9 mm**
- Seed deposition accuracy: **1.6 mm**
- Imaging Modality: **U/S**
- Application: **PSI**

Current Robotic Systems (cont'd)

CHUG robot



(a)

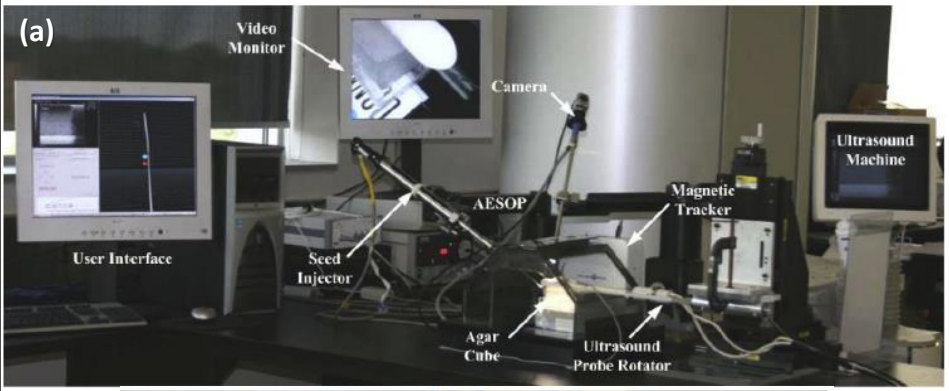


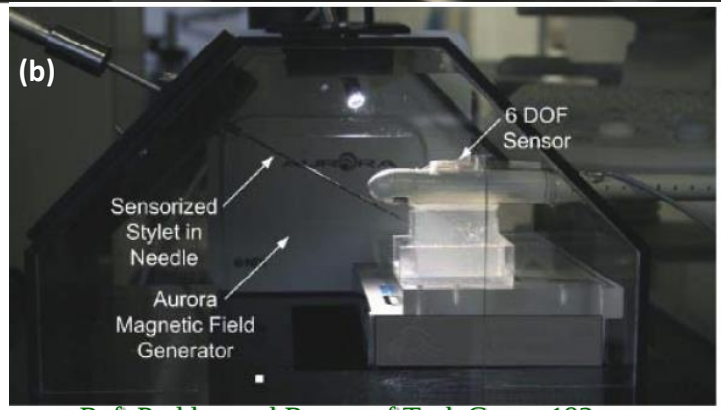
- DOF: **5 DOF**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: 1 **mm**
- Emergency stop: **Yes**
- Imaging Modality: **U/S**
- Application: **PSI**

Ref: Podder et al Report of Task Group 192

Current Robotic Systems (cont'd)

MIRA-V robot





Ref: Podder et al Report of Task Group 192

- DOF: **5 DOF**
- Number of Needle: **1**
- Seed Delivery: **Manual**
- Needle Withdraw: **Manual**
- Needle-tip positioning accuracy: **0.9 mm**
- Emergency stop: **Yes**
- Imaging Modality: **U/S**
- Application: **PSI**

Robotic System Safety Issues

- **Delay in procedure**
- **Undesired robot/patient movement → physical injury**
- **Placement error of needle/seed**
- **Incorrect number of delivered seeds**
- **Needle buckling/breaking**

Ref: Podder et al Report of Task Group 192

Conclusion

- Improvement in accuracy and precision
- Reduction of radiation exposure to medical staff
- Robotic systems are different in automation level & functionalities
- Standardized for MIS

Thank You!