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# Generation of Real-Time Optimal Carrier Landing Trajectories

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# Optimal Trajectories for Carrier Landing: Computation of LREs

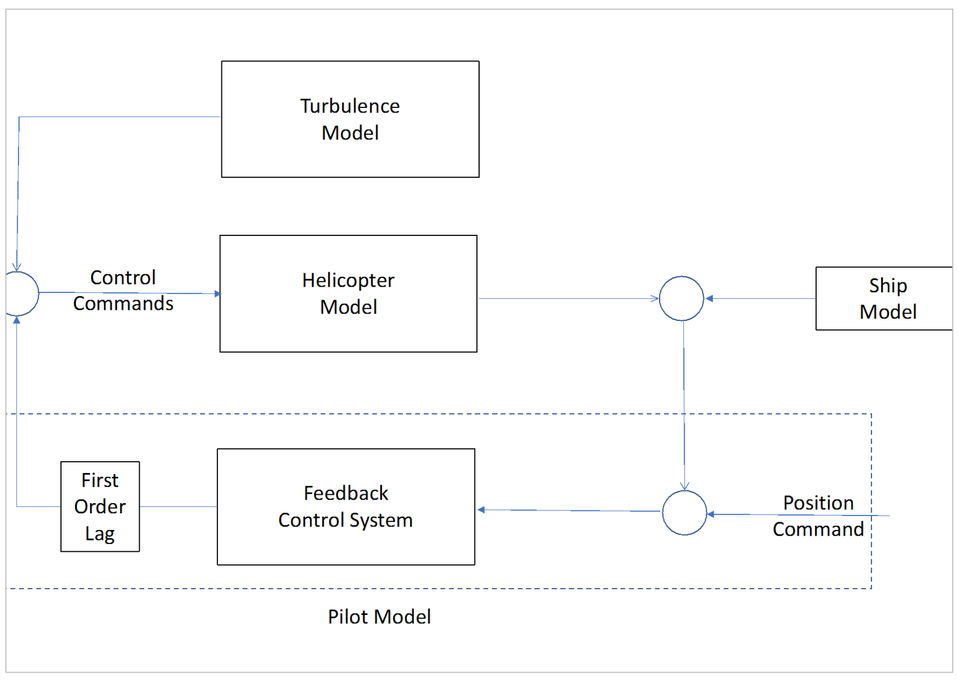
Naval Postgraduate School

## CHALLENGES & OBJECTIVES

- Today US Navy invests millions of dollars to generate Launch and Recovery Envelopes (LREs) for carrier landing of helicopters
- The process for computing LREs requires computationally expensive modelling and lengthy at-sea validation and verification
- Develop a methodology for efficient computation of preliminary LREs for use by operators and engineers
- Develop a computationally efficient tool for rapid prototyping of LRE envelops in various landing configurations

| Ship Class | H-53 | V-22 |
|---|---|---|
| CG 47 | Not Certified | Not Certified |
| CVN 68 | Minimal Expansion | Spot 6,9 Expanded |
| CVN 78 | No DI Planned | FY 16 |
| DDG 51 | Not Certified | Not Certified |
| DDG 79 | Not Certified | Not Certified |
| FFG 7 | Not Certified | Not Certified |
| LCC 19 | H-53D ONLY Generic | Not Certified |
| LCS 1 | Not Certified | Not Certified |
| LCS 2 | Not Certified | Not Certified |
| LHD 1/LHA 6 | Spots 1,2,3,4,8 Minimal Expansion | Spots 1,3,8 Generic |
| | Spots 5,6,7,9 Expanded | Spots 2,4,5,6,7,9 Expanded |
| LPD 17 | Minimal Expansion | Spots 1,2 Minimal Expansion |
| | | Spots 3,4,5,6 Generic |
| LSD 41/49 | Expanded | Generic |
| T-AH 19 | Not Certified | Not Certified |
| T-AK 3005 | Generic | Not Certified |
| T-AK 3008 | Generic | Not Certified |
| T-AK 3015 | Generic | Not Certified |
| T-AK 3016 | Generic | Not Certified |
| T-AK 3017 | Generic | Not Certified |
| T-AKE 1 | Generic | Minimal Expansion |
| T-AKR 300 | Generic | Not Certified |
| T-AKR 312 | Generic | Not Certified |
| T-AO 187 | Expanded | Not Certified |
| T-AOE 6 | Generic | Not Certified |
| T-AVB 3 | Generic | Not Certified |
| T-EPF 1 (JHSV) | Minimal Expansion | Not Certified |
| T-ESB 3 (MLP AFSB) | FY16 | No DI Planned |

*Record of Existing Fleet LREs*



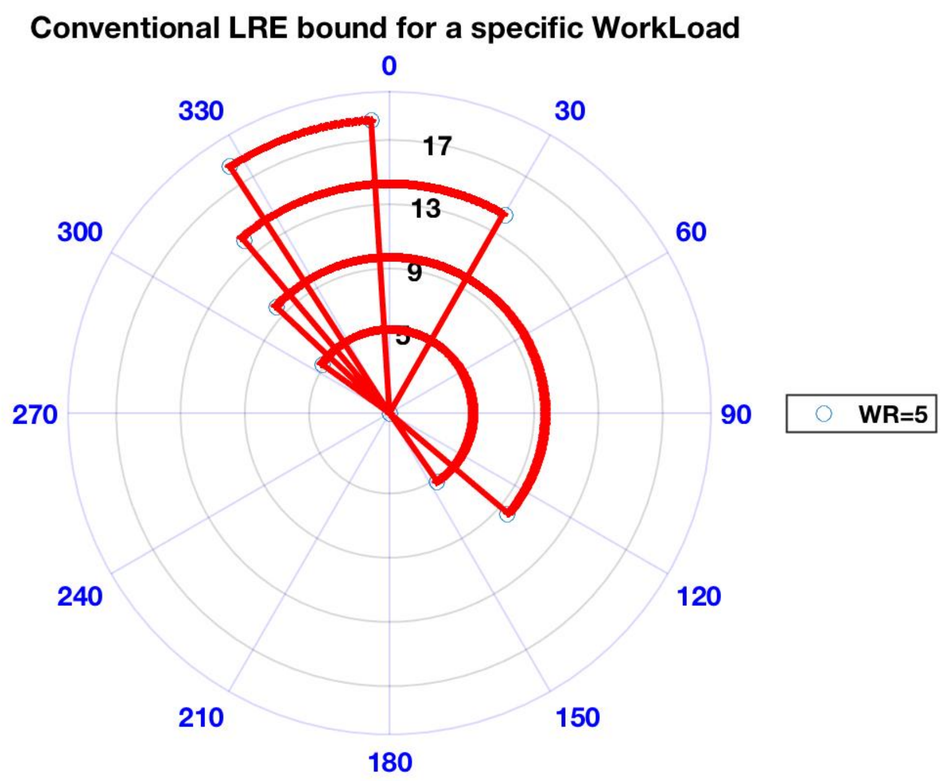

*Block Diagram of the Computational Methodology Developed*

## METHODOLGY

- Leverage existing **generic** models of
  - Ship/Helicopter Dynamics
  - Equivalent pilot control model
  - Pilot Workload Model
- to
  - Develop computationally efficient method for rapid design of preliminary LREs

## FINDINGS AND CONCLUSIONS

- Developed a Matlab based tool for computation of preliminary helicopter landing LRE
- The tool produces an LRE within a few seconds – first complete integration of all the models
- The resulting LRE can be used by operators and mission planners to determine operational range and safety bounds required for at-sea testing
- Expected to save the fleet millions of $$$$ and lives of personnel




*Preliminary LRE obtained by our tool*

## FUTURE WORK

- Utilize fleet specific
  - Ship models
  - Helicopter models
  - Pilot rating models
- Utilize better pilot workload models using
  - regression
  - machine learning and AI

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